# THE BOYS' AIRPLANE BOOK

BY A. FREDERICK COLLINS

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# THE BOYS' AIRPLANE BOOK

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BY

A. FREDERICK COLLINS

MEMBER
THE ROYAL AERO CLUB OF THE UNITED KINGDOM

*Author of*
*"The Boys' Book of Submarines," "Inventing for Boys,"*
*"Handicraft for Boys," "How to Fly," Etc.*

*WITH NUMEROUS ILLUSTRATIONS, WORKING*
*DRAWINGS AND DIAGRAMS*

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TO

RAYMOND ALBERT ZEITLER

# A WORD TO THE BOY

The airplane is the greatest invention of this or any other age. Ever since the human race made its first appearance on this spinning earth of ours man has wanted to fly.

Back there in the early days, when his only weapon was a stone or a club, and he lived in a tree or a cave, he felt the need of flying to get away from the fierce monsters that hard pressed him from time to time. His only reason, then, for wanting to fly was to *escape* from his natural enemies. But bird flight was not for him.

It was only after countless centuries of much wishing and very little thinking, and a century or so of real experimenting that he invented the flying machine, for that is what the airplane really is. Then came on the Great World War and the airplane gave to man-flight a new purpose and this was *pursuit.*

The reason the airplane proved such a formidable fighting machine in pursuing the enemy lies in the fact that it is not only, by long odds, the swiftest moving vehicle that has ever been invented, but it is the only freely moving one and, hence, it can go anywhere in a straight line.

Since the idea of flying as a means of escape passed with the extinction of prehistoric man, and the purpose of pursuit ceased to exist after the war was over, these have given way to a much more important purpose and this is *transportation.*

Those who are most interested in aviation are doing everything they can at the present time to prove that the airplane is the greatest of all transportation schemes. To demonstrate its practical value long distance flights are being made everywhere and all the time and with wonderful success.

On May 8, 1919, Lieut. Commander Read, an American naval officer, with a crew of four men flew in the NC-4, an American seaplane, from Rockaway, Long Island, N. Y., to Plymouth, England, *via* Trepassey, Newfoundland, the Azores, and Lisbon, Portugal, a total distance of 3,925 miles, in 57¼ hours' actual flying time. Her longest straightaway flight was 1,200 miles from Trepassey to the Azores and this was made in 15 hours and 18 minutes.

But even more startling than this achievement was the magnificent and spectacular attempt of the Australian pilot Harry G. Hawker and Lieut. Commander Grieve, R. N., to make a non-stop flight from Newfoundland to Ireland in a Sopwith machine. They *hopped off* from St. Johns on May 18, flew half way across the Atlantic and then had to alight because of an accident to the cooling system of the engine. They were picked up a little later by the Dutch tramp steamer *Mary.*

Then on June 14, Capt. John Alcock, of England,

and Lieut. Arthur W. Brown, of the United States, *hopped off* in a Vickers-Vimy biplane from Quida Vidi Bay, Newfoundland, and made a magnificent straightaway flight to Galway Bay, Ireland. The distance is 1980 miles and they successfully made the perilous crossing in 16 hours and 12 minutes, which means that they flew at the rate of 120 miles an hour.

What would Columbus think if he could rise up and see these pioneers of aërial navigation crossing the ocean in a sixth as many hours as it took him days to do it? And suppose you think about the fastest steamship that is now afloat which makes the trip in a shade less than five days, while the very first airplane to fly across did it in about one-seventh of the time.

Because flying is here and is the greatest of all modes of transportation you ought to know how airplanes are built and how they fly, and the way you can learn is to build and fly models, and I have written this book to tell you how to do it.

A. FREDERICK COLLINS.

The Antlers,
Congers, New York,
July 3, 1919.

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# THE BOYS' AIRPLANE BOOK

## CHAPTER I

## THE EARLIEST FLYING CREATURES

SEVEN million years passed between the time the first flying creature beat the air with its wings and the beginning of this century when the first man-carrying, heavier-than-air machine sailed the empyrean blue under its own power.

Now man had watched the flight of birds for 100,000 years before he himself was able to leave the ground and fly. From this you will gather that time is long and invention is comparatively slow and that the human race has small aptitude for imitating nature.

This, then, is the reason it took so eternally long to bring the machine that we now call the *airplane* to a state where it could be made to keep up a sustained flight and, hence, like all other useful schemes it represents a lot of finely sifted ideas cleverly combined, rather than a single clean cut invention.

**How Reptiles Changed Into Birds.**— If you will look at a snake and then at a bird you will probably not be able to see that they resemble each other so that you could notice it and yet science tells us that the beautiful birds which so delight the eye and ear have been evolved from the hated family of reptiles.

Now the words *evolved* and *evolution* are the same, except that the first is a verb and the second is a noun, and both mean that all forms of life as we know them to-day are the result of a series of changes in earlier and simpler forms.

To get an inkling of the evolution that brought forth birds from reptiles we shall have to go back some seven million years to what is called the *Mesozoic era* which was the age when reptiles were the highest forms of life on earth.

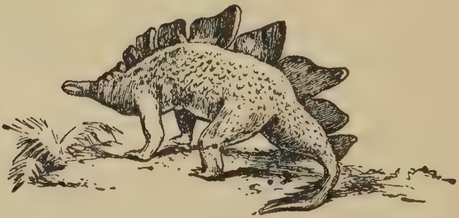

FIG. 1.—A DINOSAUR THAT WALKED ON ALL FOURS

In that dim and distant age there were all kinds of reptiles including (1) those that crawled about as snakes do now; (2) monsters with cute little heads, feet formed of hoofs or claws, zigzagged backs and great saw-like tails, and (3) flying lizards.

To the second class belonged the *dinosaur* (from the Greek words *dinos,* which means *terrible,* and *sauros,* meaning *lizard* and pronounced di'-no-saur).

Likewise there were many kinds of *dinosaurs* (plural), some walking on all fours as shown in Fig. 1 and some on their hind-legs which were formed like those of a bird as shown in Fig. 2. All were, however, most outlandish looking creatures, which on first sight seemed to have had their origin in a bad dream. But you can't blame nature, for it's pretty hard to make a nice little bird the first time out of a reptile.

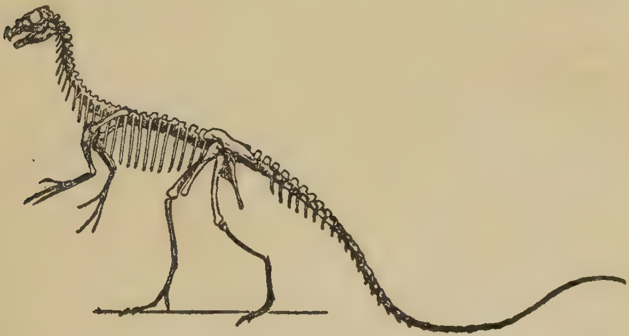

FIG. 2.—THE SKELETON OF A BIPEDAL DINOSAUR
*(American Museum of Natural History, New York. Redrawn from photograph)*

These latter dinosaurs were the chief link that connected the reptiles that crawled on the ground with the first winged lizards that flew through the air, and if you could examine the skulls and skeletons of these creatures you would see that they were very much alike in all respects. Further the *bipedal* dinosaurs, that is those that walked more or less upright on their hind legs, had three and sometimes four toes ending in sharp claws, and, finally, another kind had a horny bill, or beak, which covered the front of its jaws.

All of this goes to show that nature was working changes as fast as she could in some of the dinosauria so that they could fly and they had reached a point where the short front legs were ready to develop into wings.

**The First Feathered Creature to Fly.**— The *archæopteryx* (so called from the Greek words *archaios,* which means *ancient* and *pteryx* meaning *wing* or *bird,* and pronounced ar-ke-op′-te-riks) was the first feathered creature that ever flew.

This early attempt of nature to make something that would fly was evolved from a dinosaur whose front legs were changed into short wings and there you have a general picture of the archæopteryx.

Hence this strange creature, hardly beast or bird, had sharp and conical teeth that set separately in its jaws like those of some lizards; it was about the size of a crow and had a shortish blunt beak. There was also a big difference in the way the bones of its wings and those of our birds were arranged, while its tail was very unlike the birds of our time in that it was simply the tail of the dinosaur.

It did have feathers though, and these put it into the class of birds, for by their feathers shall ye know them. Its feathers were very like those of our present day birds but since its wings were short and the muscles it used for flying were small, it seems certain it could not have flown to any great extent. But it was

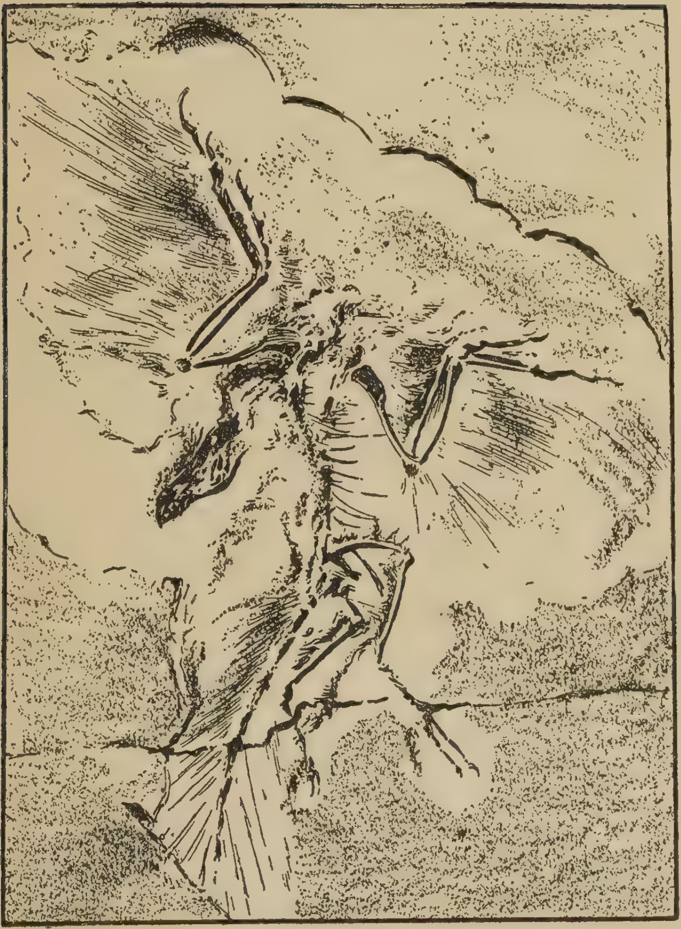

FIG. 3A.—THE FOSSIL OF THE ARCHÆOPTERYX

(*American Museum of Natural History, New York. Redrawn from photograph*) useful in that it marked the beginning of real birds.

The feathers of the archæopteryx were of the same kind and it is supposed arranged[1] the same way as those of our modern birds except those of its posterior end, which, instead of springing from a three cornered stubby tail like the latter, stuck out on each side of its long jointed bony appendage. A picture of this *rara avis*[2] is shown in Fig. 3B.

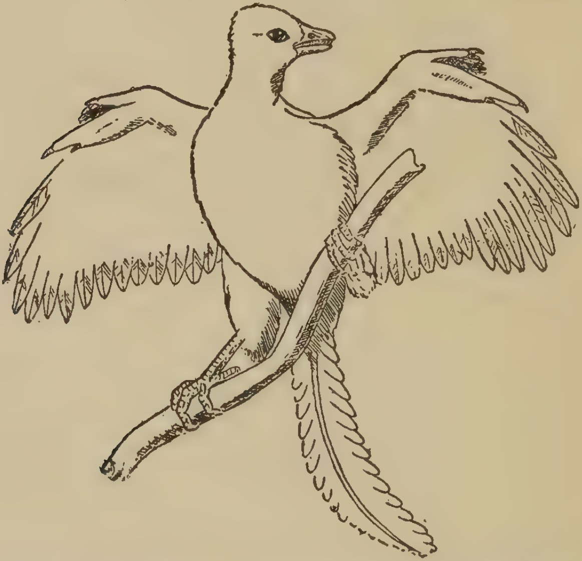

FIG. 3B.— ARCHÆOPTERYX AS RECONSTRUCTED BY MR. PYCRAFT
(*American Museum of Natural History, New York*)

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[1] The feathers of Archæopteryx were not surely *arranged* like those of modern birds — many wordy battles have been waged over this question.

[2] In Latin this means a rare bird.

**The Largest Flying Creature.**— When nature was making her experiments with creatures to inhabit the air she almost made a flying machine. At any rate she evolved the *pteranodon,* a kind of *pterodactyl* (from the Greek words *pteron,* which means *wing* or *feather,* and *dactylos* which means *finger,* and pronounced ter-o-dak′-til), the largest creature that ever flew.

This great flying reptile, which lived near the end of the Mesozoic age, did not look nearly as much like a bird, though it was an infinitely better flier, than the archæopteryx which preceded it. The pteranodon was really a giant lizard with great bat like wings which measured 20 feet from tip to tip.

Talk about the fabled *roc*[3] of Sinbad the sailor, *griffins*[4] and *dragons*[5] they were not to be compared with the pteranodon, for they were fabled winged monsters while it was a real flying lizard. The *condor,* a very large vulture of South America, has a wing expanse of something like 10 feet, and Fig. 4 shows at a glance the difference in size between this largest of living birds and the great extinct flying creature.

The pteranodon had a head out of all proportion to its body, being some 4 feet long and, as you will see

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[3] This is a mythical bird of Arabia which the oriental imagination pictured as being so large that it could carry off an elephant to feed its young.

[4] A fabulous animal with the body of a lion and the head and wings of an eagle.

[5] Another fabulous monster, but in this case the body is that of a scaly lizard and to this was added a pair of wings.

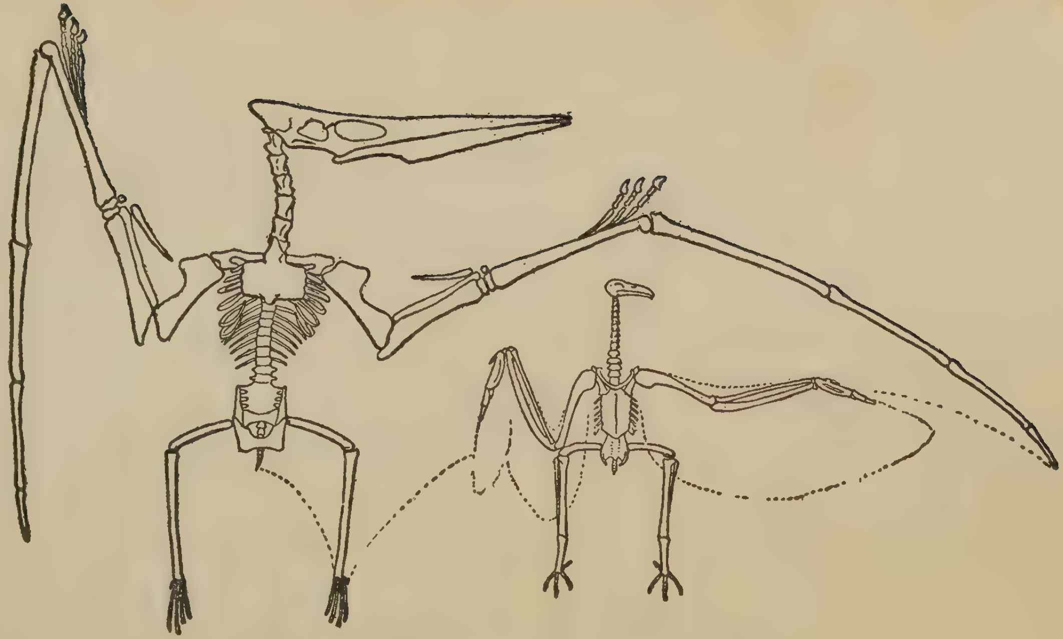

Fig. 4.— The Pteranodon and Condor Compared

Since the publication of "The Greatest Flying Creature" it has been proved that the Peteranodon was provided with a long, backwardly projecting crest, as asserted by Prof. Marsh and denied by Williston.

*(Courtesy of Smithsonian Institution)*

from the picture following this chapter, it was nearly all beak; this horny mouth-part which may have been covered with a hard layer of skin was shaped very like a dagger and like the birds of our age it had no teeth. That it was a fish hunter and eater is shown by the remnant of a pouch at the under part of its beak near its throat just as is found in some fish eating birds[6] at the present time.

The wings of the pteranodon were very large for the size of its body and they were formed of a kind of *membrane,* that is a thin sheet-like substance. They reached from the very long fingers of its *pinions* to its short hind legs in quite the same fashion as the wings of a bat.

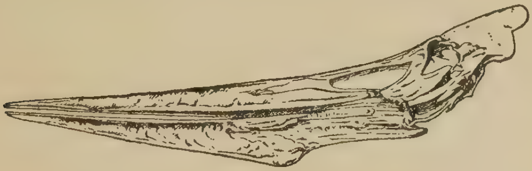

FIG. 4.—SKULL OF THE PTERANODON
*(Courtesy of Smithsonian Institution)*

The bones of this creature were hollow and about as light as if they had been made of a piece of cardboard rolled up into tubes; indeed, when it was built up in the flesh it only weighed 25 or 30 pounds, being much lighter in proportion to the spread of its wings than any other bird that ever lived. The wonderful lightness and great wing surface of the pterodactyl made it possible for it to sail through the air for long stretches at a time, and it made use of its great powers of flight to sweep the sea in search of fish.

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[6] The pelican, penguin and cormorant are fish-eating birds.

Curiously enough this early flying creature played a very considerable part in making inventors of our own time believe a heavier than air flying machine could be built, as you will presently see and this is the chief reason I have told you all I can about it.

**How We Know These Creatures Lived.**— You may wonder how it is known to a certainty that one kind of a dinosaur had feet like a bird, that the teeth of the archæopteryx were like those of a lizard, or the beak of the pteranodon was shaped like a dagger, when all of these strange creatures lived some four million years before the first man ever trod the earth.

The way these things are known is simple when you are let into the secret and it gives me pleasure to initiate you. First of all you must know that a *fossil* is the remains of a plant or an animal, or an impression of them made in the rocks while the latter were being formed and which have been preserved in this way all these millions of years.

Now only two skeletons and a single feather of the archæopteryx have ever been found and these came from the fine, smooth-grained limestone that is dug from the quarries at Solenhofen, Bavaria. One of these skeletons is now in the British Museum and the other is in the Berlin Museum, and both are so well preserved and natural that you don't have to guess to know that they once belonged to a most outlandish kind of bird.

But you may say, suppose the skeletons do remain, how is a fellow to tell from them how the bird itself looked when it was living seven million years ago. To answer your question I'll have to tell you about the great French naturalist Cuvier (pronounced Ku'-ve-a), who lived a hundred years ago.

He got up a system by which he could tell from the bones of either a recent or a fossil animal not only the family to which it belonged but he could draw a picture of the whole skeleton from it and then the outline around it of the very way the animal or bird looked when it was alive. This system is called *comparative anatomy* and if you want to know more about it get Cuvier's book called the *Animal Kingdom.*

As for the pteranodon, skeletons have also been found of it and wonderfully clear impressions of its wings have been preserved in the fine limestone of the Solenhofen quarries, and further, fish bones and scales have been found imbedded in the stone with it and this adds to the belief that fish was its chief food.

Following the laws of evolution these first flying creatures were gradually changed into the various kinds of birds, until by the time man appeared they were pretty well developed, and thus from the very beginning the desire to fly like them was strong within him.

But nature had other plans for man to fly, without growing wings on his body and so making a bird of him. She intended to make him master of the air just as she has made him master of the land and sea, and that was by having him invent a high speed, power-driven machine.

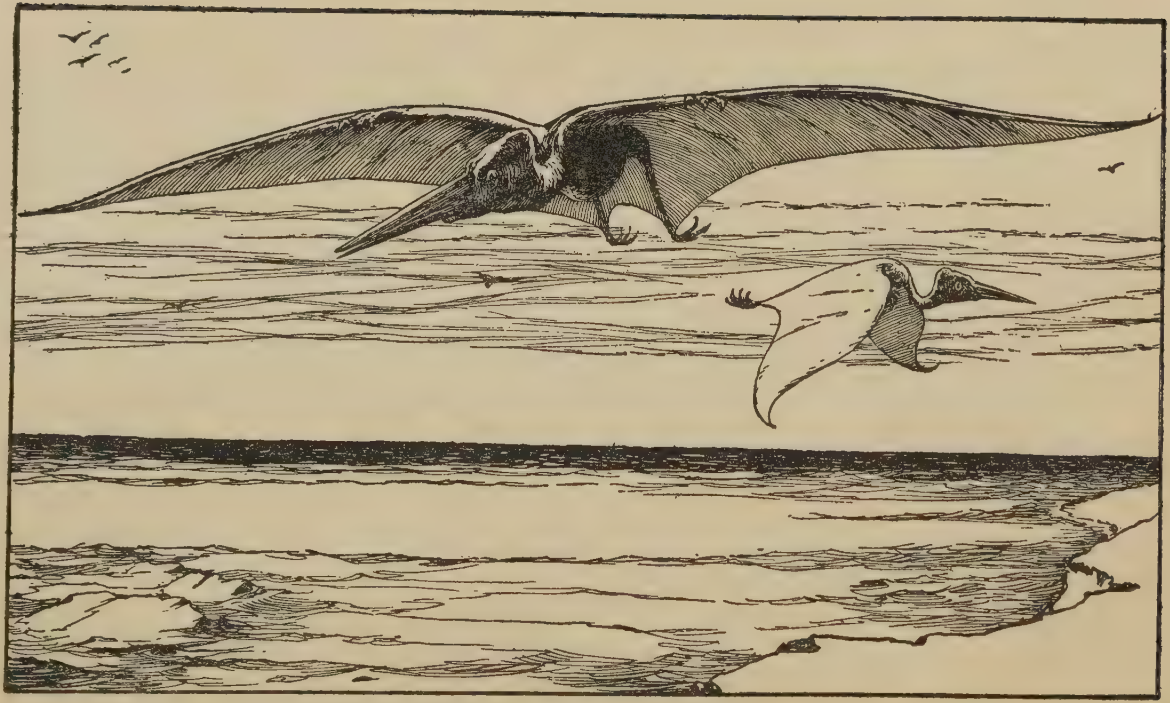

Fig. 5.— The Pteranodon in Full Flight

## CHAPTER II

# WHEN MAN BEGAN TO FLY

It seems pretty certain then, that primitive man got the idea that he would like to fly from the birds, and having once gotten it he had small patience to wait for nature to grow wings on him by the long process of evolution.

However, he showed a glimmer of intelligence in the matter for he set about thinking how the thing might be done, and then, bringing his imitative powers into action, he devised wings like unto the feathered tribe. But having more imagination than mechanical ability his first ideas were limited to a mental picture of himself soaring through interstellar space.

And why not, for a man and a bird are not so very different, at least as far as their skeletons are concerned as a glance at Fig. 5 will show [1] although this fact he probably was not aware of.

### The Wishing Stage

**Icarus and His Mythical Wings.**— I do not suppose for a moment that Icarus (pronounced Ik′-a-rus), the boy of Greek mythology,[2] whose father made a pair of wings for him and is alleged to have fastened them to his shoulder-blades with wax, was the first to try to fly with home-made wings, but he is the first of whom there is any record.

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[1] From the Smithsonian Report of 1900.

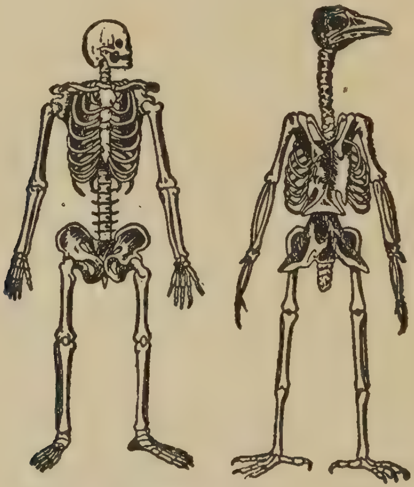

FIG 5.—THE SKELETON OF A MAN AND THE SKELETON OF A BIRD, DRAWN TO THE SAME SCALE, SHOWING THE CURIOUS LIKENESS BETWEEN THEM. (*Courtesy of Smithsonian Institution*)

The story runs that he flew so high to escape from Minos, the king of Crete, who had the *Minotaur*[3] in his labyrinth, that the sun melted the wax and he came down, wings and all in a *tail-spin*[4] into the sea. (See Fig. 6.) While this latter part of the legend is fiction pure and simple, it shows that away back there when civilization was young, man longed to fly.

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[2] You can read the full account in *Ovid's* poem.

[3] This legendary monster was half bull and half man. It was confined in the labyrinth built by Dædalus in Crete.

**The Flying Pigeon of Archytas.**— About 400 years before Christ there lived a wise old Greek named Archytas, (pronounced Ar-ki′-tas) who was famous at figures, philosophy and mechanics.

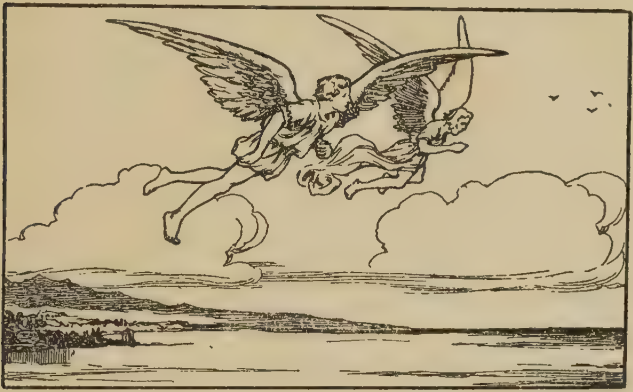

FIG. 6.— ICARUS AND HIS WINGS

He thought deeply about nearly everything including flying and to prove how easily it could be done he made a pigeon that history tells us flew, just as mythology tells us Icarus flew. But the quill of the historian must have been bent for if his mechanical pigeon had really flown it is quite certain that flying models would have been built from that time on which they were not.

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[4] When an airplane dives to the earth and then revolves round its longitudinal axis it is called a *tail-spin.*

**Vinci and His Folding Wings.**— Just about the time that Columbus discovered America, that is in 1492, Leonardo da Vinci (pronounced Vin′-chi), an Italian painter, sculptor, architect, and *certes* he was gifted with inventive ability, conceived the idea of making wings that would fold so that they would spread out on the down stroke and so beat the air, and close up on the up stroke and thus cut the air. Although he did not actually build the wings his plans had in them the element of a real invention.

**The First Recorded Attempt to Fly.**— In 1508 Albert Damian of Scotland made the first real attempt to fly of which there is any record. He made a pair of wings of the feathers of fowls and arranged these so that he could fasten them to his body and work them with his arms.

So certain was this would-be *aviator* (pronounced a′ve-a-tor) of his ability to use his bird-like wings, that he boasted he would fly across the English Channel to France. Instead, when he made the attempt to start from an elevation his wings, or his strength, or both, failed him and in landing he broke his leg. He also sprained his mind too, for he laid the entire blame of the accident on his wings which should have been covered with eagle's feathers rather than those plucked from barnyard roosters.

**What Borelli Thought of Beating Wings.**—

Nearly a century and a half later, that is to say about 1650, Giovanni Alfonso Borelli, an Italian physician and mathematician, made a study of the motion of birds.[5]

He figured out that the muscles of the wings of birds, or *pectoral muscles* as they are called, were so much stronger, in proportion to their size, than the muscles in the arms of man, that the latter could never expect to fly with beating wings. This negative statement of Borelli's was one of the few that learned men ever made that happened to be true. Still it did not keep those who wished to fly from trying and this is as it should be or there would be no such thing as progress.

## The Gaseous Stage

**Roger Bacon's Hot-Air Scheme.**— While men in the early days were wishing for wings science was forging ahead a little, at least it had been found out that hot air was lighter than air at ordinary temperatures and hence that it would rise.

Now there lived in Merrie England one Roger Bacon,[6] called the *Admirable Doctor,* from 1214 to 1292, or thereabouts. He was a learned monk and as *alchemy* was a great study in those days he was busy trying to transmute the baser metals into gold, searching for the *alkahest*[7] and now and then making a little gunpowder.

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[5] See his "On the Motion of Animals."

[6] Do not confound Roger with Francis Bacon, the English philosopher, who lived in Shakespeare's time about three centuries later.

His idea of a device that would fly was by filling something with hot air when of course it would go up. His plan was to make a large hollow globe of very thin copper and fill it with *liquid fire,* that is, a burning liquid, but he never tried out the scheme.

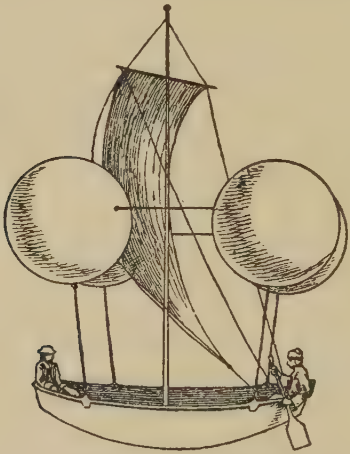

FIG. 7.—LANA'S VACUUM AIRSHIP

**Lana's Vacuum Airship.**— Four hundred years later Francisco Lana, an Italian monk, concocted the first plans for an *airship.*[8] This consisted of four hollow globes made of thin copper and he thought he could make these lighter than the outside air by pumping the air out of them.

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[7] An imaginary liquid which the alchemists believed would reduce all substances into their original elements.

[8] An *airship* is a machine lighter than the air and an *airplane* is a machine heavier than the air.

Of course the instant the air was pumped out the globes would have collapsed, due to the pressure of the air on them from the outside, but this is one of the things in physics that Lana had never dreamed of. A sail was to be fixed to a support that held the globes and a boat was to be suspended from them as shown in Fig. 7.

**The Coming of the Balloon.**— About the time that Washington crossed the Delaware, Henry Cavendish, an English chemist, discovered *hydrogen,* the lightest gas known.

Not long after Joseph Black, a Scotch chemist, tried filling bladders with the gas to make them rise, while Tiberio Corello, an Italian experimentalist, was more successful, for he actually filled soap bubbles with hydrogen, when they rose and floated in the air until they broke.

**The Montgolfiers Make the First Balloon.**— To the Montgolfier Brothers of France is due the credit of making the first balloon, which they did in 1782. Many stories are told of how they found that hot-air would cause a paper balloon to ascend but whether it was purely a chance discovery or the result of careful experiment is not known.

Their first trials were with paper bags — they were paper-makers — filled with hot air made by holding them over a small *brazier.*[9] These ascended so well that they next made a great bag of linen nearly 30 feet in diameter and the air was heated by a fire of

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[9] A pan, usually on legs, used for holding burning coals.

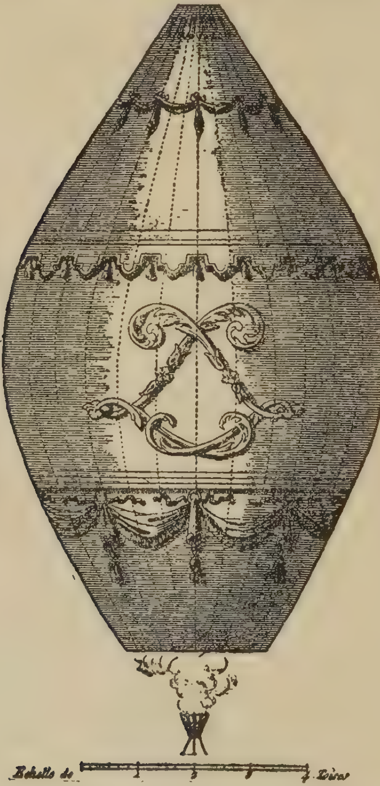

FIG. 8.— MONTGOLFIERS MAKE. THE FIRST BALLOON
*(From "Aërial Navigation" by A. F. Zahm. Courtesy of D. Appleton and Company)*

chopped straw. This experiment was as successful as the others and they had the pleasure of seeing it rise to a height of half a mile or so and travel a distance in a horizontal line of some five miles. Their balloon is shown in Fig. 8.

The world and his wife were all agog over the new balloon which many felt sure was to solve the puzzle of how to navigate the air. The brothers were summoned by royal command to appear before the King and Queen of France at Versailles (pronounced Ver-sal′-ye) so that they might see with their own eyes this new wonder of the air.

For this exhibition they used a large, gorgeously colored balloon and to it they hung a wicker cage in which they had placed a duck, a rooster and a sheep. The balloon rose gracefully and after floating for half a mile came gently to the earth.

**The First Aëronauts.**— The first human beings, not to fly, but to float through the air, or *aëronauts* as they are called, were Pilatre de Rozier and the Marquis d'Orlandes.

They used a huge balloon nearly 75 feet high and kept it inflated by means of a brazier hung in the center of the opening. The two daring balloonists, the first human beings who ever made an ascension, took their places in a huge wicker basket, and the balloon was let go, when it floated rapidly upward. After a short trip the heroes of the air finally landed safe and sound.

**The Invention of the Gas Balloon.**— After the ascent of de Rozier and d'Orlandes the balloon was the most talked of thing of the hour. Within two months Charles and Robert, (these were their surnames), of Paris, built a great balloon of silk, varnished it to keep it from leaking, and put a valve in it for safety's sake.

This they filled with hydrogen gas made by dissolving iron filings in dilute sulphuric acid. It took four days to inflate it and when this was done the inventors got into the basket, the ropes were loosed and it shot up into the air almost like a rocket. After covering a distance of 15 miles they landed in a field without mishap. (See Fig. 9.)

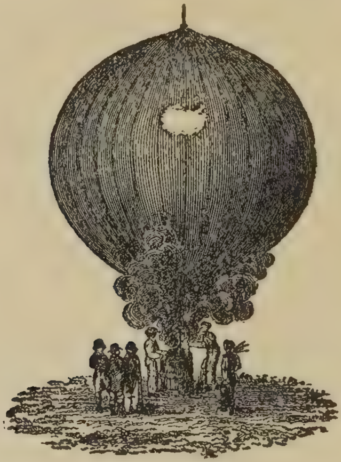

FIG. 9.—THE INVENTION OF THE GAS BALLOON
*(From "Aërial Navigation" by A. F. Zahm. Courtesy of D. Appleton and Company)*

Next Charles made an ascension alone and as the weight the balloon now carried was less by half it reached a height of two miles and then descended without the least difficulty. From these experiments it seemed as if the balloon was quite a safe vehicle in the air.

**The Dirigible Balloon, or Airship.**— It was soon found that the spherical balloon was at the mercy of every wind that blew and that if it was to be made of any real service some way must be found to steer it. Hence the invention of the *dirigible* (pronounced dir′-i-ji-bl, and comes from the Latin *dirigo* which means to direct) balloon, that is one which could be steered.

The first thing, then, a *dirigible* — as a balloon of this kind is called for short,— must have is (1) a rudder to steer it with and (2) some kind of power to drive it with. Since the lifting power of a balloon is limited, and it has such a large surface exposed to the wind, the motive power to propel it with must be very light and powerful. The father of the dirigible was General Meusnier for it was he who got up the idea in 1783.

**Giffard Builds the First Dirigible.**— Henri Giffard of France was the first to actually build and try out a dirigible and he was also the first to give the balloon the shape of a cigar. His dirigible was not very successful because the motive power he used was not nearly strong enough to push it against the lightest breeze, but he was able, in still air, to make it go around in circles.

Next Dupuy de Lôme, also of France, built a dirigible and tried to drive it by means of a 20 foot propeller which was turned by eight men but he had little more success than Giffard before him.

**An Electric Driven Dirigible.**— The electric battery and electric motor having come to the fore as a power unit, the next effort, which was made by Gaston and Albert Tissandier in 1884 was far more encouraging.

Their dirigible was driven by a bicarbonate-of-potash battery which weighed very nearly 500 pounds; this energized an electric motor which weighed 120 pounds and this in turn rotated a propeller 9 feet in diameter. About 1⅓ horse power was developed and this drove the dirigible along at the rate of about four miles an hour.

**The First Real Dirigible.**— The experiments of the Tissandiers showed that if a powerful enough motor was used the dirigible would be in truth what its name indicates. So it was not long until Renard and Krebs of the French Balloon Corps built a dirigible and used a motor in it that weighed in the neighborhood of 200 pounds and developed about 8½ horse power. With this dirigible, whose propeller was placed in front, they were not only able to go against a light wind but actually return to the place where they started from. Fig. 10 shows their dirigible.

**The Spectacular Santos-Dumont.**— In the next ten years the gasoline engine made gigantic strides as a motive power and in 1900 it was largely used on motor cars. Here then was a compact and light engine for the horse power it developed and it furnished a nearly ideal engine for navigating the air.

In 1901 Alberto Santos-Dumont, a young Brazilian who went to Paris to carve a career out of the air for himself, used a gasoline engine for the first time in a dirigible and, hence, was the first to apply this modern motive power to aërial navigation. After experimenting with four balloons he built the *Santos-Dumont V*, which had a length of 112½ feet, a diameter of 19½ feet and a capacity of 715 cubic yards. A four cylinder 16 horse power engine turned a propeller 13½ feet in diameter at a speed of 200 revolutions per minute. It is shown in Fig. 11.

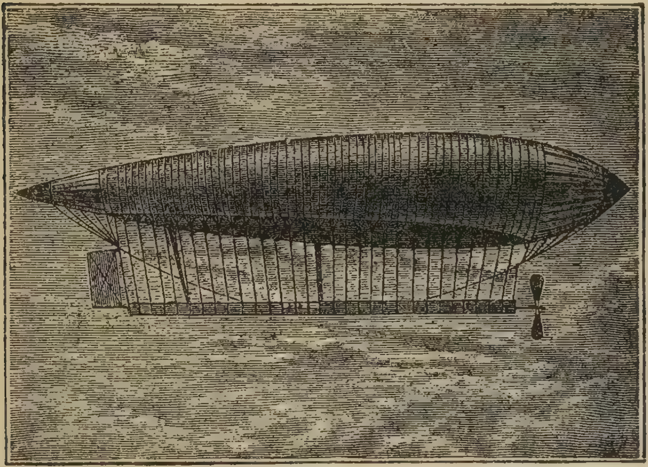

FIG. 10.— RENARD AND KREBS ELECTRIC DIRIGIBLE
*(From "Aërial Navigation" by A. F. Zahm. Courtesy of D. Appleton and Company)*

So cleverly did Santos-Dumont manage this dirigible that Henri Deutsch offered a prize of $20,000 to the first aëronaut who should start from the Aërostatic Park, sail around the Eiffel Tower nine miles away and return to the starting point in thirty minutes.

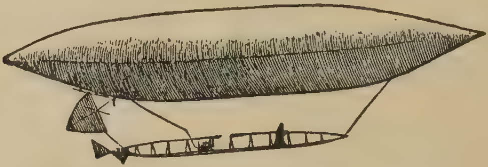

FIG 11.— SANTOS-DUMONT'S DIRIGIBLE

The aëronaut built the *Santos-Dumont VI* which was a larger and more powerful dirigible and he made the round trip, losing only by ten seconds. The committee, however, awarded him the prize.

**The Rigid Dirigible Zeppelin.**— In 1895 Schwarz of Austria conceived the idea of making a more substantial dirigible than the bag itself offered by bracing it inside with an aluminum framework.

This idea was later adopted and worked out by Ferdinand von Zeppelin (pronounced tsep′-pe-lin) of Germany. His first dirigible — many have since been built — was an enormous rigid airship 610 feet long and 39 feet in diameter. The aluminum skeleton framework shown in Fig. 12 divides the gas bag into 17 compartments, or separate balloons.

Rigidly fixed to the aluminum frame were two aluminum cars and in each car was a gasoline engine of about 15 horse power. The engines drove four

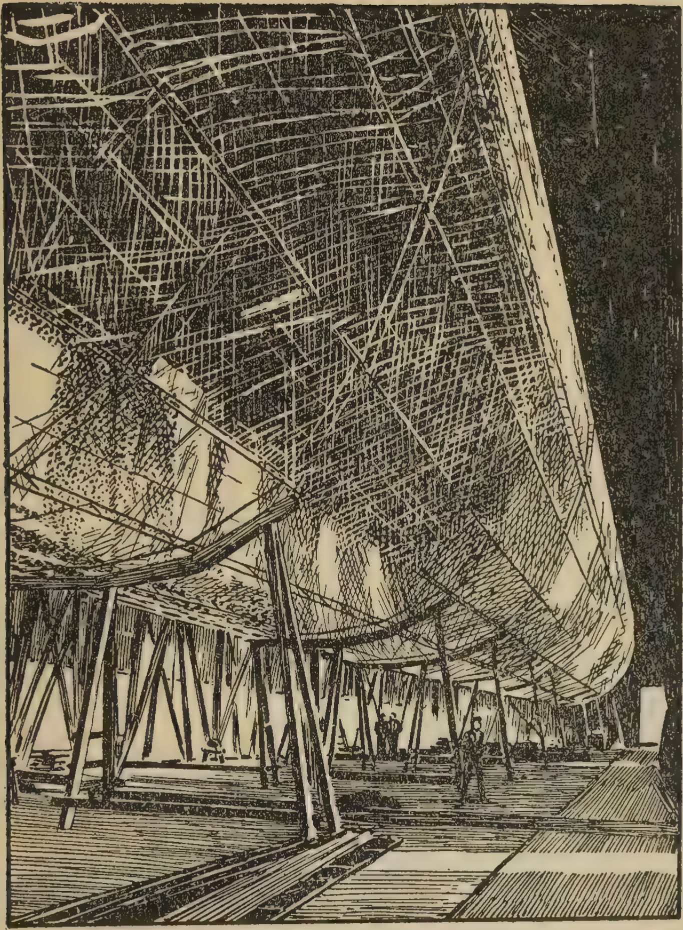

FIG. 12.— THE ZEPPELIN RIGID DIRIGIBLE

*(Redrawn from photograph furnished by Smithsonian Institution)*

aluminum propellers at 1000 revolutions per minute.

On its trial ascent it rose 1,300 feet and covered a distance of 3¾ miles in 17 minutes in a given direction. On its next ascent it rose 2,000 feet, made fair headway against a 7-mile wind, and it was under good control.

## The Striving Stage

This stage of mechanical flight is really the continuation of the wishing stage. While in the beginning, if not, indeed, nearly the end of the balloon period, it seemed to point the way for man to fly — yet as a matter of precise statement a dirigible does not really fly but floats and noses its way through the air.

What was wanted was not a huge lighter-than-air contrivance which was at the mercy of every wind that blew but a small heavier-than-air machine that would rise and fly against the wind by virtue of its speed.

**How the Birds Fly.**— This brought the art of flying right back to where it was before the discovery of the balloon, and that is, to the birds. By this time, though, man had observed that birds fly in two different ways and these are (1) by beating their wings, and (2) by making their wings rigid and *soaring*.

If you will look at a humming bird, a pigeon or a wild goose you will see that they beat their wings all the time they are flying while the sea-gull, the turkey buzzard and the condor [10] sail through the air for long stretches at a time without once flexing their wings — that is by soaring.

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[10] The pteranodon was also a soaring creature.

Not only this but since steamships had been invented much attention had been given to the propeller, which is a kind of screw — and as the steam engine and electric motor were well known the means seemed to be at hand to propel a heavier-than-air machine upward and forward.

Models of different kinds for soaring flight were made and propelled with rubber-strand motors and these flew well, but to make a man-carrying machine on the same principle was about as hard a problem as the human brain ever tackled. Yet the airplane did arrive and hence I will describe the development of this kind of a machine only.

**Kites, the Forerunners of the Airplane.**— A kite, as you well know, is made of two, or better, three, crossed sticks with a string bound round their ends to give it shape when it is then covered with paper or muslin. A tail is fixed to an ordinary kite to balance it but with an Eddy kite or a Hargrave box-kite a tail is not needed.

Who the first boy was to make a kite, or *plane,* for this is what it is, that would stay in the air when held by a string against the wind, history does not tell us but that it originated in China there is small doubt.

Here then was another heavier-than-air object which would rise and stay up and this, as well as the birds, very early led to the belief that if a kite which would stay up in a wind of, say, 25 miles an hour, was fitted with a propeller and some kind of power which would drive it at the rate of 25 miles an hour it would likewise go up and if no wind was blowing it would speed ahead at the rate of 25 miles an hour.

With soaring birds and flying kites before them to serve as models, there were men who had imagination enough to foresee that a machine if properly built and powered, ought to fly.

**Cayley, the Inventor of the Glider.**— George Cayley, an Englishman, was one of the first to believe that a machine with rigid wings would fly. Away back in 1769 he invented a toy[11] that screwed its way through the air and nearly 30 years later he built a *glider*.

Now a glider is simply a free kite the plane of which sets as a small angle from the horizontal instead of at a large angle as in an ordinary kite. Cayley's glider had 300 square feet of wing surface and when a man held on to it and ran against the wind it would rise and carry him with it quite a little ways through the air.

**The Origin of the Word Aëroplane.**— The word *aëroplane* came from the Greek *aēr,* which means motion in the air, and *plane,* meaning a more or less flat surface. It was Wenham, of England, who, in 1867, coined the word *aëroplane* and this is the name he called his glider, which was also large enough to carry a man. Wenham had an idea that this glider could be made to fly by means of a power driven propeller but he made no attempt to do this.

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[11] This was the first helicopter, as it is now called, a description of which will be found in the next chapter.

**The First Steam Engine Model Airplane.**— The first airplane to have an engine put into it was a beautiful little model built by Stringfellow, of Australia, who exhibited it at the Crystal Palace in London in 1868.

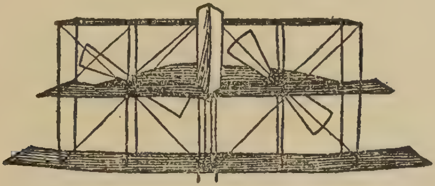

FIG. 13.— STRINGFELLOW'S MODEL STEAM ENGINE AIRPLANE
*(Redrawn from photograph furnished by Smithsonian Institution)*

It looked very like a modern triplane and was powered with a ⅓ horse power steam engine, the lightest and at the same time the most powerful engine for its size that had ever been built. According to its builder it had lifted itself from the ground but at the exposition he ran it forth and back under its own power on a stretched wire. It is shown in Fig. 13.

**The First Full Sized Airplane.**— Shortly after Stringfellow exhibited his little model Phillips of England built a large airplane with wings formed of some 50 thin strips of wood placed one above the other like an open Venetian blind.

To the wings a frame shaped like a boat was fixed and this was secured to a truck with wheels on it which in turn set on a circular wooden track. A steam engine and boiler was mounted in the frame and drove a propeller at about 400 revolutions per minute. Fig. 14 shows how it was made.

When all was ready the machine was tethered to a post in the center of the track to keep it from jumping off. The airplane was run round the track and at times the speed was high enough so that the rear wheels were lifted from the rails but the front wheel did not rise; hence the machine never really flew.

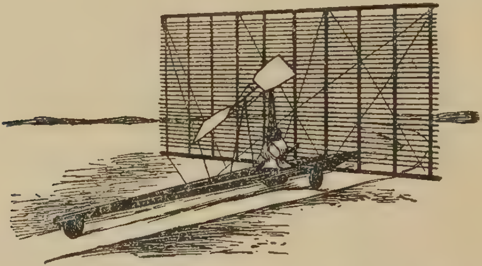

FIG. 14.— PHILLIPS' STEAM ENGINE MODEL

**Maxim's Great Airplane.**— Hiram Maxim, the well known British[12] inventor of machine guns, high explosives and the like, drew up plans for a great airplane in the latter part of the '80's.

It had two great bat-like wings, or planes, which measured 50 feet from tip to tip. On each side of these main planes were a number of other and smaller planes while a rudder in front and one behind formed the steering gear. The motive power consisted of two steam engines each developing 180 horse power and these drove two propellers.

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[12] He was born in the United States.

Its total weight when ready to fly was fully 3½ tons and to keep the machine from flying away before the inventor had learned the trick of managing it he built a third rail overhead. On one trial when the airplane was running at a goodly speed it left the ground and broke through the upper rail but at this interesting stage the steam was shut off and so ended the experiment.

**Langley's Steam Driven Airplanes.**— The late Samuel P. Langley who was the Secretary of the Smithsonian Institution, Washington, D. C., began experimenting in 1887 with a view of producing an airplane.

He began the work by making a whirling table of large size which was rotated by a steam engine. To an arm of the whirling table he fixed an end of a spiral spring and to the free end of the latter he attached a thin brass plate one foot square and weighing two pounds. The plate moved along a scale so that the pull of it could be noted. Now by revolving the table at different speeds he found that the *greater* the speed of the plate the *less* power was needed to keep it in the air.[13]

Up to 1891 Langley had built over 30 model airplanes driven by rubber strand motors and these made flights of from 1 to 3 seconds duration. After these models he constructed three large steam driven models and one of these, (see the picture at the end of Chapter III) flew repeatedly over distances of nearly a mile.

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[13] These tests are fully explained in "Experiments in Aerodynamics," by S. P. Langley and published by the Smithsonian Institution, Washington, D. C.

So successful were these flights that the Government provided Langley with $50,000 for the development, construction and test of a large airplane. The large man-carrying machine when it was finally built weighed 830 pounds and the planes had 1040 square feet of sustaining surface. A gasoline engine which weighed 52 pounds and developed 10 horse power was installed in it and everything was made ready for the trial which took place in 1903.

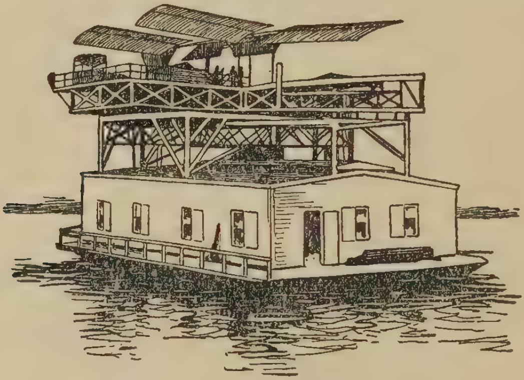

FIG. 15.—LANGLEY'S MAN-CARRYING AIRPLANE
(*Redrawn from photograph furnished by Smithsonian Institution*)

Like the steam-driven models this large machine as shown in Fig. 15, was to be launched from a track on top of a house-boat on the Potomac River. The aviator took his seat in the airplane and it was launched but, unfortunately, a guy post of the machine caught on the launching car. The airplane was dragged down and plunged forward into the water about 150 feet in front of the house-boat. The Government was not willing to spend more money on the experiments, and the great work of Langley came prematurely to an end.[14]

## The Successful Stage

There were two schemes open for the successful development of the airplane and these were (1) to work the machine out on paper, make experiments and then build it, and (2) to begin with simple gliding flights and work up to a powered machine, and both had their adherents.

**The Gliding Flights of Lilienthal.**— By 1890 enough had been done to show that soaring flight was possible but Otto Lilienthal of Germany had the idea that an aviator must needs know how to balance his machine in the air first and unless he could do so he would certainly come to grief.

To this end he built a glider with great bat-like wings and to which he fixed a tail and a rudder as shown in Fig. 16. In the middle of and directly under the wings there was a pair of padded struts and over these he would throw his arms and then running down a hill against the wind it would carry the glider up and he would sail along to considerable distances.

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[14] A complete account of these trials will be found in the Smithsonian reports for 1897, entitled "Researches and Experiments in Aerial Navigation," by S. P. Langley.

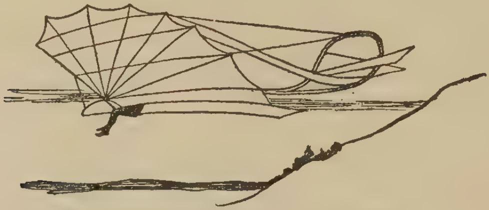

FIG. 16.— LILIENTHAL'S GLIDER

He made hundreds of flights but finally in 1896 the glider in which he was soaring was upset by a gust of wind and he never recovered from the injuries he received.

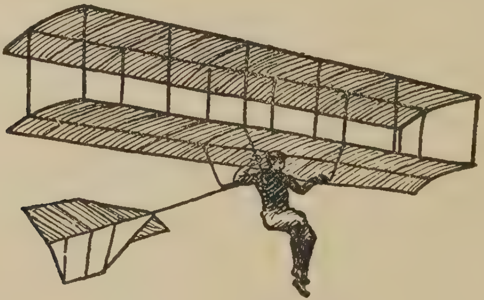

FIG. 17.— CHANUTE'S GLIDER

**Chanute and His Gliding Experiments.**— Octave Chanute, an engineer of Chicago, began gliding where Lilienthal left off. His first glider was of the *monoplane,* that is, single plane, type, but as it did not behave in the air the way he thought it should he built a *biplane* with *cambered* [15] wings as shown in Fig 17.

The *double-decked* glider of Chanute was very much stronger than the single decked gliders that had been built before, while the tail was made so that it could move up and down a little, and altogether it was much more easily managed and far safer than the glider of Lilienthal.

**The First Airplane to Fly.**— It remained for Wilbur and Orville Wright, two bicycle mechanics of Dayton, Ohio, to build the first heavier-than-air machine and fly in it.

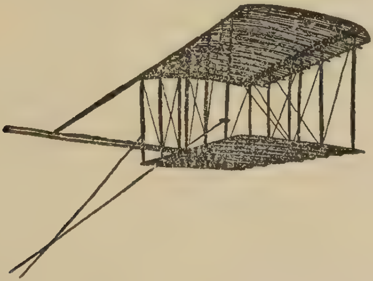

FIG. 18A.— THE FIRST WRIGHT GLIDER

In 1900 the brothers constructed a Chanute glider, as shown in Fig. 18A, but they left off the tail, put on an *elevation plane* [16] in front and steered the machine on the horizontal by *warping* [17] the wings.

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[15] Cambered means curved.

[16] The tail planes used for steering the airplane up or down.

[17] To *warp* the wings means to bend the front edges more or less; *ailerons* are now used instead and these are described in Chapter VII.

Instead of hanging on the glider they laid flat face downward on the lower plane as shown in Fig. 18B just as you lie on a sled. In the following three years they made thousands of glides without once falling and they got so expert they could sail through the air for a full minute. These record breaking gliding experiments were all made on the sand dunes at Kitty Hawk, North Carolina.

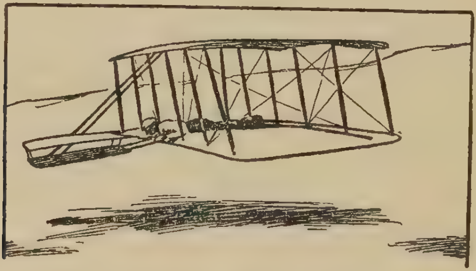
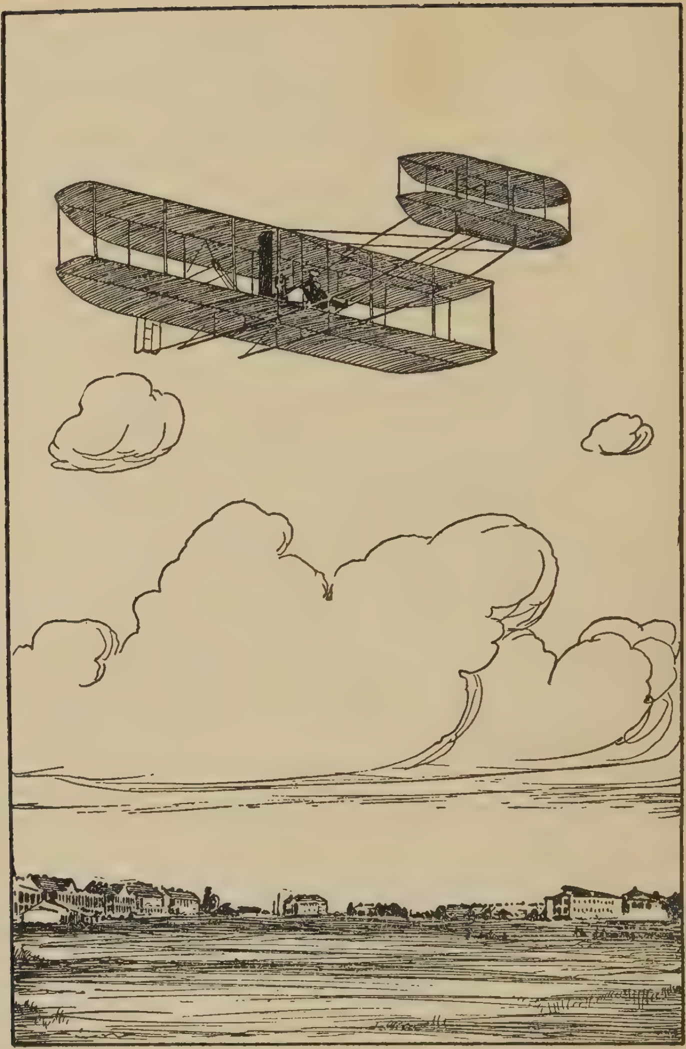


FIG. 18B.—THE WRIGHT GLIDER

When they had learned how to control the glider under all conditions of wind they fitted it with a gasoline engine of some 25 horse power and a pair of propellers. They made the first man-carrying engine-driven flight in December, 1903, and the first long distance flight near Dayton, Ohio, in 1905.

Finally in 1908 with improved machines Orville made the first public flight in this country, flying for 1 hour, 14 minutes and 20 seconds at Fort Meyer, Virginia, while at the same time Wilbur broke his brother's record by flying for 1½ hours and carrying a passenger with him at Le Mans, France.

And so this then is the long record of broken hearts and necks but which resulted in man-flight and ended at last the quest of the flying machine.



THE WRIGHT BROTHERS' FIRST AEROPLANE
*Fort Meyer, Va., Sept. 9, 1908*

# CHAPTER III

## THE FIRST FLYING MODELS

In the early days there were three promising schemes by which man hoped to build a heavier-than-air machine that would fly and these were (1) the *helicopter* (from the Greek word *helix* meaning *spiral* or *screw*), that is a machine fitted with propellers that would screw its way up and through the air; (2) the *orthopter* (from the Greek *orthos* meaning *straight*) a machine that beats its wings and (3) the *aëroplane,*[1] or just *airplane* as it is now called for short, that is a machine with rigid wings, or planes, and driven through the air by a propeller.

**The First Power Driven Helicopter.**— It was only a toy but it flew wonderfully well and much was hoped from it, for little acorns into great oaks grow. It was invented by two Frenchmen, Launoy and Bienvenu who showed it in flight in 1784.

It was formed of a thin wooden rod about 5/16 of an inch in diameter and 9 or 10 inches long. A cork was fixed on the top end of the rod and four feathers were stuck into it at a small angle to form a screw. Another cork with a 3/8 inch hole in it was fixed to the middle of a strip of whalebone over a hole of the same size as shown in Fig. 19.

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[1] For the source of this word see page 30, Chapter II.

The whalebone and cork, which formed a revolving element, were then slipped over the stick; a cord was fastened to each end of the whalebone and the ends of the cords were secured to the top of the stick near the fixed cork. Four more feathers were stuck into the lower cork and set at a slight angle as before but in the opposite direction to those in the upper cork.

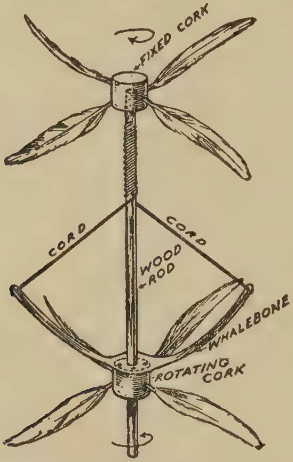

FIG. 19.—LAUNOY AND BIENVENU'S
TOY HELICOPTER

Now by turning the free cork with the whalebone on it around, the cords wind up on the rod and this bends the whalebone into a bow and so stores up energy in it. When the helicopter is released the tension of the whalebone tends to unwind the string and this rotates it and the propeller fixed to it and as the two propellers turn in opposite directions they exert quite a lift and the machine goes up in the air.

**How to Make a Better Helicopter.**— You can make a far better helicopter than Launoy and Bienvenu because you can use rubber strands for the motive power while they had to use whalebone.

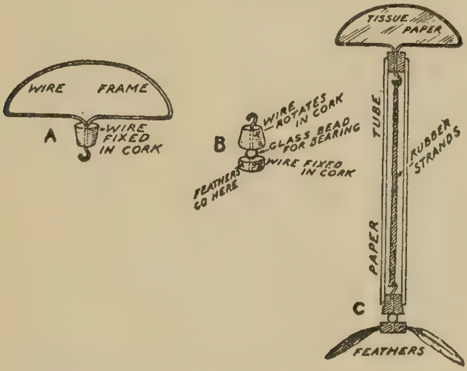

Fig. 20.— A Rubber Strand Helicopter

A.— The Tail
B.— The Bearing
C.— The Helicopter Complete

Make a strong tube about ½ an inch in diameter and about 7 inches long, by rolling up a thick sheet of writing paper and smearing it with glue as you go along. Fit a cork into each end and through the center of one of them force the end of a thin piece of wire and form a hook on it; bend the long end of the wire in the shape of a semicircle and force the free end into the cork as shown at A in Fig. 20.

Take another cork and force a bit of wire through the center of it so that it will not slip and bend it to form a hook; slip a bead over the other end to form a bearing and push the wire into another cork as shown at B. Next get a couple of rubber bands, loop them over the hooks of each cork and push the corks into the ends of the tube.

Cover the wire semicircle with tissue paper and, finally, stick a couple of feathers into the lower cork opposite to and at a slight angle with each other. Now wind the feathered end, or propeller, round until the rubber bands are well twisted; boost it into the air and let it go when it will sail high and away until its power gives out.

**How to Make a Screw Helicopter.**— This toy helicopter which also screws its way through the air is a wonderful climber but different from the little helicopter just described; it has no motive power of its own and, hence, it is not a flying machine in the true sense of this term.

To make this simple flying toy get a sheet of tin 1 inch wide and 5 inches long; mark out the shape of a propeller on it as shown by the broken lines at A in Fig. 21 and cut it out with a pair of shears or tinner's snips. Drill two 1/16 in. holes through it at the places marked with the circles and bend the blades at a slight angle to each other and in opposite directions as shown at B.

Drive two brads in one end of an empty spool as shown at C so that they will slip easily through the holes in the propeller. Get a round stick ½ an inch in diameter and 5 inches long; whittle down one end nice and round and make it just a trifle smaller than the *bore*, that is the hole in the spool, as shown at D.

Take a yard of strong cord, or fishline, wind it on the spool, put the spool on the stick and the propeller on the end of the spool. Give the string a quick pull and the propeller will sail away through the air a hundred feet or so. No helicopter has yet been built that would lift a man.

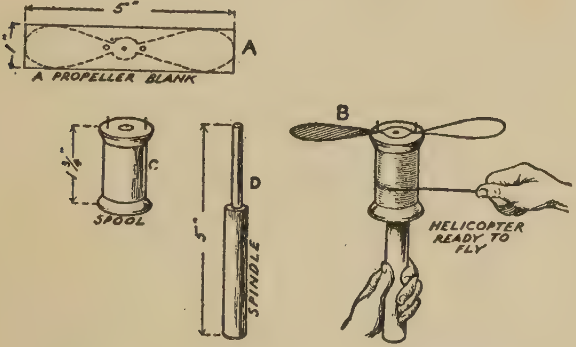

FIG. 21.—HOW TO MAKE A SCREW HELICOPTER

**Penaud's Mechanical Bird.**— This orthopter is the only kind of a mechanical bird with beating wings that was ever known to fly. M. A. Penaud, a Frenchman, built the first one in 1865 and I dare say he and every one else thought the secret of the heavier-than-air flying machine had been discovered. But, alas and alackaday, it was nearly forty years after, that the first man made a sustained flight in a power driven machine and then it was not in an orthopter.

You can make this clever toy which beats its wings and flies very much like a real bird by following the description and looking at the picture shown in Fig. 22. Bend a couple of lengths of aluminum wire into two Y-shaped supports 1½ inches high and flatten them where the holes are drilled. Twist the ends of these wires tight to a light but strong stick of wood about ½ an inch in diameter and 10 inches long; make a strong but short support of wire and fix it rigidly to the other end of the stick.

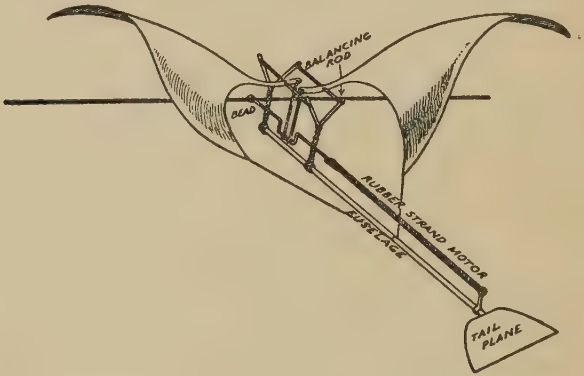

Fig. 22.— Penaud's Beating Wing Bird

Make a little crankshaft of an iron or brass wire ⅛ inch thick and slip it into the lower holes in the Y supports; put a bead on the front end and bend an eye on the wire to keep it from pulling out; solder, or otherwise fix, a piece of wire about 12 inches long to the front end to give the machine the proper balance and you can use it to wind up the rubber strand motor with.

The frames for the wings can be made of split bamboo and let the front ends project to pivot the wings in order to get the leverage to move them by. Drill two holes in the extreme ends and two more farther back so that they can be pivoted to the cross-bars set in the ends of the prongs of the Y supports. Make two connecting rods of wire and hook these on to the ends of the wings and over the crankshaft.

Cover the bamboo frames with Japanese silk and tie the rear ends of the wings to the stick that forms the backbone. Hook on half a dozen good rubber bands or strands to the crankshaft and the rear support and your mechanical bird is ready to fly.

Wind up the rubber strand by turning the balancing wire round a hundred times or more; hold the bird about level with your eyes and point it slightly up, give it a gentle shove and let it go. The untwisting rubber strands will turn the crankshaft and as this rotates it works the connecting rods which in turn beats the wings up and down at an angle and drives the bird ahead through the air.

**Penaud's Soaring Bird.**— Penaud made another flying toy in 1874 and as it was more simple, far speedier and covered a greater distance it is easy to see — after it was done — that the principle on which it worked would serve for a man-carrying machine.

This small beginning of the airplane consisted of a flat, fixed wing or plane, a flat tail and a propeller, all of which were held in place by a stick of wood and it was driven by a rubber-strand motor.

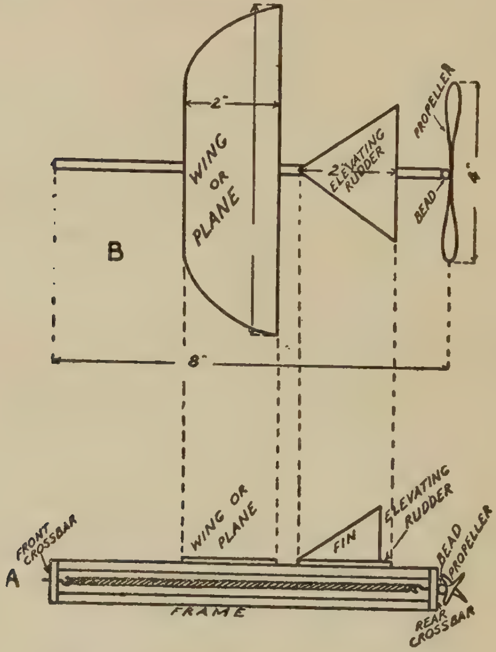

FIG. 23.—PENAUD'S SOARING BIRD
A.—Side View of the Bird
B.—Top View of the Bird

To build one make a thin frame of light, strong wood as shown at A in Fig. 23 and in one of the cross-bars fix a wire hook so that it cannot turn; drill a ⅛ inch hole through the other and rear cross-bar and push a wire 1 inch long, with a hook on it, through the hole. Slip a glass bead over the other end of the wire that projects through and solder on a 4-inch, two-bladed propeller which you can cut out of tin.

To fly the little model wind up the rubber strands, using the propeller as a key to do it with. Hold it in front of you with its nose pointing slightly up, give it a gentle push and it will soar gracefully through the air to a distance of 50 feet or more.[2]

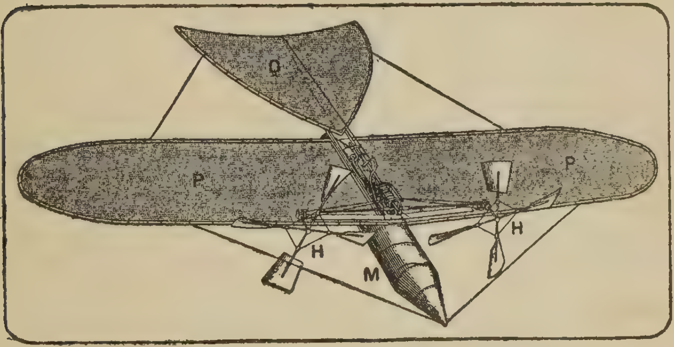

FIG. 24.— TATIN'S COMPRESSED AIR MODEL
*(From "Aërial Navigation" by A. F. Zahm. Courtesy of D. Appleton and Company)*

**Tatin's Compressed Air Model.**— Victor Tatin of France was the first, as far as I know, who made an actual flying model of an airplane that used power other than rubber strands. This he did in 1879 when he built and flew the model shown in Fig. 24.

[2] Mr. Langley began his elaborate experiments by making and flying this toy airplane.

This model was a monoplane mounted on wheels and driven by a pair of propellers which in turn were rotated by an oscillating cylinder engine[3] worked by compressed air. The latter was contained in a steel tube 4 inches in diameter and 36 inches long and it was tested to stand a pressure of 300 pounds to the square inch.

This tube not only held the compressed air but it served as the backbone for the machine itself. The little airplane, complete with its engine, weighed a trifle more than 3¾ pounds and had a wing surface of 100 square feet.

A circular board walk 46 feet in diameter was built for it to run on and it was held in by a rope fixed to a stake in the center. When the engine was started the model quickly gathered speed and when it was running at the rate of 18 miles an hour it lifted itself and flew about 20 yards.

**Hargrave's Compressed Air Monoplane.**— Of course you know what a box kite is but you may not know that it was invented by Lawrence Hargrave of Australia. He was working on flying models and the now well known box kite was one of his schemes for a wing surface.

Hargrave built several powered flying models but his most successful one was a monoplane, driven by a single propeller which was turned by a compressed air engine. It had no wheels for starting as you will see by looking at Fig. 25.

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[3] Any engine that will run with steam can be run with compressed air.

**Phillips' Steam Engine Model.**— The first flying model airplane to be driven by a steam engine was made by Phillips of England. The wings of his machine were formed of a lot of thin, narrow curved strips, fixed one over the other like an open Venetian blind.

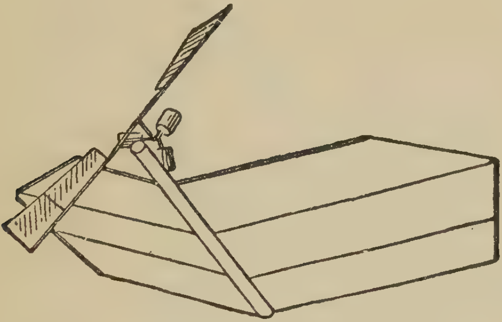


Fig. 25.— Hargrave's Compressed Air Monoplane

*(From "Aërial Navigation" by A. F. Zahm. Courtesy of D. Appleton and Company)*

It was the first time that *cambered,* that is curved, wing surfaces had ever been used and this scheme is employed on all airplanes to-day. The planes were 12 feet long and had a wing surface of some 136 square feet and it was, as you will agree, quite a large model.

A steam engine and boiler was mounted in the frame of the airplane and this drove a propeller 6 feet in diameter. The machine was mounted on a track with wheels and altogether it weighed in the neighborhood of 330 pounds. It ran on a circular track and was held within bounds by a rope tied to a post in the center of it. When the airplane was running at a speed of 28 miles an hour it left the track and flew well for quite a little distance.

**Langley's Steam Engine Models.**— Langley began his experiments in mechanical flight with Penaud's little model airplane, and he built over 30 rubber-strand motor models so that he might learn how a machine driven by its own power, would act when flying in free air. And right here is the key-note of this book and that is if a great scientist like Langley could learn from these rubber-powered models, *you* can learn.

After experimenting with the rubber-strand models he built several miniature airplanes that were driven by compressed air and finally he drove them with steam. His first steam-driven model that really flew was a monoplane with the wings in *tandem,* that is there were two pairs of wings and these were placed in a line back of each other. There were two propellers which were set between the two pairs of wings.

The little engine was a marvel of lightness for its power, since it weighed only 20 ounces and developed nearly 1½ horsepower while the boiler weighed but 5 pounds, making the total weight of the power plant about 4 pounds to the horse power.

This model measured 12 feet from tip to tip and the whole weight was about 30 pounds. It was launched from the top of a house-boat on the Potomac River and it flew repeatedly over distances of half a mile at speeds varying from 20 to 30 miles per hour. It is shown in full flight at the end of this chapter.

**Langley's Gasoline Engine Model.**— Before Langley built his man-carrying airplane, he designed, built and tried out a model airplane whose scale was one-fourth of that of the big machine he intended to build. It is shown in Fig. 26.

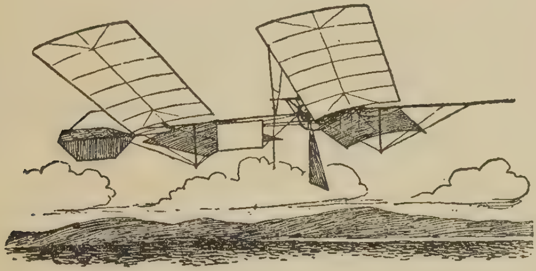
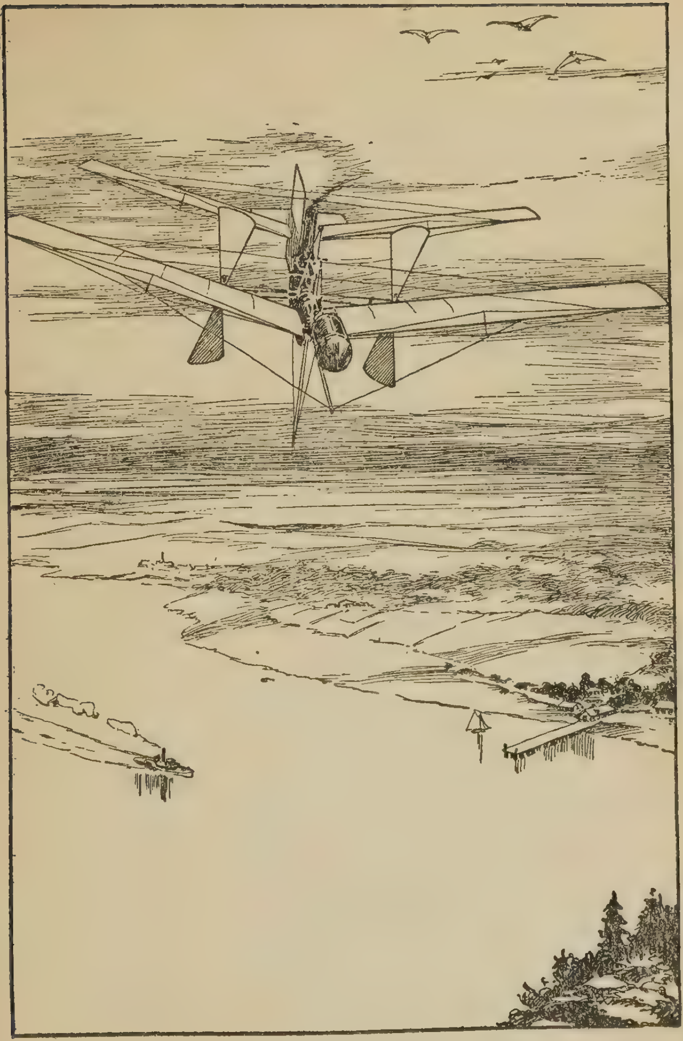


Fig. 26.— Langley's Gasoline Engine Model Airplane
*(Redrawn from photograph furnished by Smithsonian Institution)*

This model was fitted with a gasoline engine which developed nearly 3 horse power. The wings had 66 square feet of surface in them and the model complete weighed 58 pounds. When it was all ready to try out, it was shipped to a point 40 miles from Washington on the lower Potomac River.

There it was reassembled and placed on top of the house-boat where it was swung on the launching ways. It was turned about so that it faced the wind, the engine was started and the airplane was let go. The propellers drove it straight ahead for 350 feet when it circled around and dropped a little; the engine then picked up in speed and the machine flew straight ahead for a like distance. It lost headway the third time, circled, dropped and picked up again before it struck the water, but finally descended after it had flown a total distance of about 1000 feet.

This was the first sustained flight of an airplane ever made in public and it was also the first successful airplane that was ever driven by a gasoline engine. The tryout of this model was made in August, 1903, and in December, 1903 — four months later — the Wright Brothers made the first engine-driven, man-carrying flight in an airplane.



Langley's Steam Model in Flight

## CHAPTER IV

## AN EASILY MADE FLIER

THE way to know all about airplanes is, of course, to either build them, or to fly in them, or, better, to do both of these things.

But as the *art of aviation* (pronounced a-ve-á-tion) stands to-day there are only a favored few who can get *next* to it right, for a full fledged man-carrying machine costs in the neighborhood of $5000, takes a big field to *maneuver* it in and much time must be spent in practicing with it.

There is an easy way for you to get a lot of fun out of flying though and at the same time you will learn how and why heavier-than-air machines fly; and you can experiment with them at a very small cost and without the slightest risk of landing on your *cranium,* or skidding off on your ear — and this way is to make and fly *model* airplanes.

There are more styles of flying models than you can shake a stick at but it is better to make and fly the simplest kind of an airplane first and get the knack of it before you begin to work with *scale models,* that is, models patterned after the *Bleriot,* Wright and other types of commercial machines.

While all of the parts of the models described in this book can be made at home if you are a little clever with tools, to make things still easier let me whisper in your ear that you can buy whatever you need of dealers who make a business of selling model airplane supplies and all you have to do is to put the miniature machine together.[1]

But if you would rather make the models yourself you will find drawings of each part of the airplanes with the sizes marked on them, and with the descriptions that go with them all is clear enough to make the work easy, the results sure and the time you have put in well spent. So here goes.

**A Long Distance Flier.**— A simple and easily made model that will fly nearly a quarter of a mile is formed of four chief parts and these are

(1) A *frame*, or *fuselage*, as it is called in a man-carrying machine, which holds all the other parts of the model together.

(2) The *planes*, or *wings*, whose curved surfaces hold the machine in the air when it is driven hard enough by

(3) The *propellers* which are in turn turned themselves by

(4) A *motor*, and in small models this is usually made up of a pair of *skeins* of rubber *strands*.

*The V Frame.*— For this part of the model get two sticks of spruce, whitewood or pine 3/16 inch thick, 1/4 inch wide and 2 feet 11 inches long. Silver spruce is the best wood to use as it is very light and strong; whitewood is lighter but not so strong and pine will do if you can't get either of the other kinds.

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[1] Write the Ideal Airplane and Supply Co., 84 West Broadway, New York City, your wants.

Now make two wire eyes by bending a piece of iron wire ³⁄₆₄ inch thick and 3½ inches long, and then bend the wire over in the middle as shown in Fig. 27, to form a nose. These are called anchor eyes and their purpose will be seen presently.

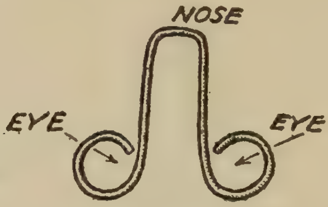

Fig. 27.—Wire Eyes for Holding a Rubber Skein

Next cut out of a sheet of *aluminum* ¹⁄₄₀ inch thick, which is No. 22 Brown and Sharpe *gauge* or of sheet tin though this is heavier and bends more easily, a strip that is 1¼ inches wide and 6¾ inches long and trim off the ends as shown in Fig. 28, making one edge 4¾ inches long.

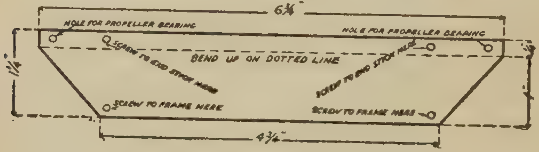

Fig. 28.—Angle Plate to Support Frame and Bearing for Propeller Spindle

Drill two ⅛ inch holes, one in each corner of the long edge of the strip; drill a 1/16 inch hole 1 inch from each corner of the long edge, and drill another 1/16 inch hole through each corner of the short edge. The larger holes are for the propeller *bearings* and the last four holes permit the strip to be screwed to the ends of the sticks but before this is done bend up the long side of the strip ¼ inch. This forms an *angle plate* and it not only holds the bearings of the propeller in place, but it also braces the sticks at the wide end of the frame.

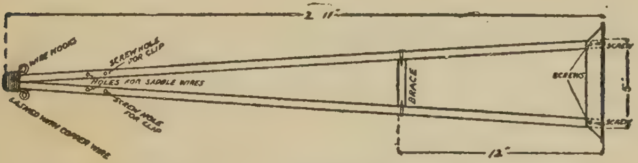

FIG. 29.—THE FRAME PUT TOGETHER SHOWING STRIPS OF WOOD, WIRE HOOKS, BRACE AND ANGLE PLATES IN POSITION.

When these parts have been made, whittle down an end of each of the long sticks so that when they are put together the other ends will spread apart about 5 inches and so make a V. Press the nose of the wire eyes (Fig. 27) round the tip of the sticks and lash them there by wrapping 18 or 20 inches of thin copper wire around the wire nose and sticks to hold them together good and tight as shown in Fig. 29.

Across the frame about 12 inches from the wide end screw a thin piece of pine to brace it and then screw the angle plate of aluminum, or of tin, see Fig. 28, to the ends of the sticks, all of which is clearly shown in Fig. 29, and the frame of your flier is done.

*The Planes, or Lifting Surfaces.*— For this flier *fiber paper* makes good planes for it is light, tough, flexible and cheap. If this is not at hand use oiled board or even very thin cardboard will do. Cut out two planes, a large, or *main one,* and a small, or *elevation* one, from whatever kind of paper you are going to use.

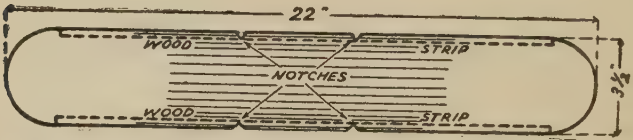

Fig. 30.— Main Plane Made of Fiber Paper or Thin Cardboard. Dotted Lines Show Where Wood Strips Are to be Glued.

The *main plane,* shown in Fig. 30, can be 22 or 24 inches long and about 3½ inches wide. Trim the ends round and cut two notches in each edge; have the first pair of notches 2 inches on each side of the middle of the plane — that is 4 inches apart — and the other pair of notches 2¼ inches from the middle — or 4½ inches apart. These notches not only serve as guides to get the frame in the middle of the plane but to hold them together as you will see in a moment.

This done, glue two strips of wood ⅟16 inch thick,

¼ inch wide and 18 inches long to each edge of the plane to make it rigid; the dotted lines in Fig. 30 show where the strips are glued on.

To hold the plane to the frame get a rubber band ¼ inch wide and 5 inches long; slip it over the plane; place the plane in position on the frame, draw the rubber band *under* the frame, stretch it on over to the other end of the plane and see that the band is caught in all of the notches. Fig. 31 shows how the band is stretched around the plane and frame.

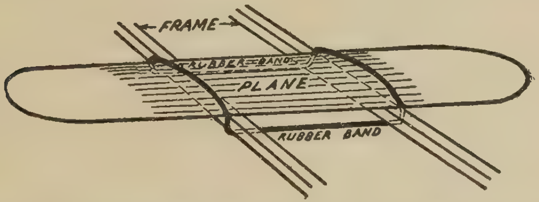

FIG. 31.—SCHEME FOR ADJUSTABLE FASTENING OF PLANES

By bending the plane a little you can make it bulge in the middle like the bear that met Algy, that is it will be *arcuated* as brother Byard used to say, or better still call it a *cambered wing* as the French named it, and you will be as right as they are.

Cut the small, or *elevation* plane out of the same kind of paper you used for the main plane; make it 3½ inches wide and 8 inches long and round off the ends as shown in Fig. 32. Cut a notch in the middle of one edge of this plane so that you can center it accurately on the frame and glue a strip of wood

1/16 inch thick, ¼ inch wide and 5 inches long on the edge of the plane in which the notch is cut.

Take a piece of thin, springy wire 12 inches long and bend it into the shape shown in Fig. 33, which is full size and slip this *saddle*, as it is called, on the sticks so that the upright wires will be about 5 inches from the tip of the frame.

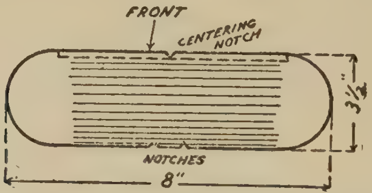

FIG. 32.—ELEVATION PLANE OF FIBER OR THIN BOARD. DOTTED LINE SHOWS WHERE WOOD STRIP IS TO BE GLUED.

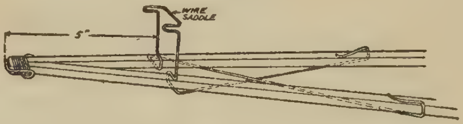

FIG. 33.—WIRE SADDLE SHOWING HOW IT IS MADE AND SET INTO THE FRAME. DOTTED LINES SHOW WIRE UNDER THE FRAME.

Slip the elevation plane with its front edge in the wire saddle and its rear edge under the ends of the wires and with the notch exactly in the middle.

*The Propellers.*—And now comes the real fine work and that is making the propellers, *spindles* and *bearings*.

Propellers made out of sheet hard fiber 1/32 inch thick are good enough for this flier. Cut out four pieces or blades exactly the same size and shape shown in Fig. 34. Next cut out of thin sheet brass two clips of the size and shape shown at A in Fig. 35; bend them over in the middle and punch four holes through the ends as shown at B.

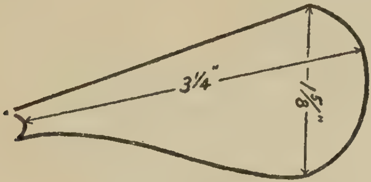

FIG. 34.—A PROPELLER BLADE

For each spindle — you'll need two — use a piece of iron wire a shade less than 1/16 inch in diameter and form a hook on one end as shown at A in Fig. 36. Now get a brass tube 1/16 inch inside diameter and ⅛ inch outside diameter and cut off two pieces, one B, ⅛ inch long and the other C, ½ inch long; take a brass washer having a hole ⅛ inch in diameter and an outside diameter of ¼ inch.

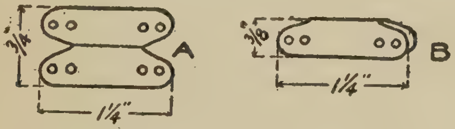

FIG. 35.—A. BRASS CLIP CUT OUT FOR PROPELLER BLADE
B. BRASS CLIP WHEN BENT

Solder this washer to the middle of the longest tube as shown at B, and then slip it over the shank of the hook that forms the spindle. This tube forms the bearing in which the spindle turns and the washer, which is now called a *collar,* prevents the propeller from being pulled up against the angle plate of the frame when the bearing is slipped through the hole in it.

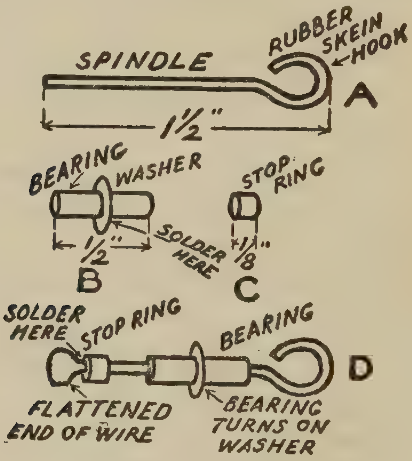

FIG. 36.—THE SPINDLE AND BEARING COMPLETE

The next move is to put the short piece, C, of brass tube, or ring over the end of the spindle ¼ inch from the straight end and solder them together; the purpose of the ring is to prevent the bearing from rubbing against the propeller. The spindle and bearings when finished are shown at D.

To assemble the propeller set the small ends of the two blades together with the sharp corners on the same and with the flattened end of the spindle between them; set the brass clip over the joint and rivet the blades to it. When all the parts are put together tight, bend the joint until the surfaces of the blades set at an angle of 90 degrees, that is at right angles, or nearly so, to each other and the spindle sets just halfway between them. This finishes up your propeller when it will look like Fig. 37.

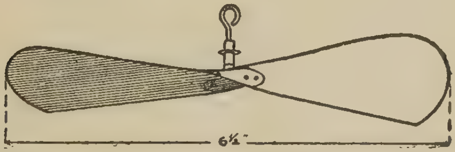

FIG. 37.—THE PROPELLER WITH SPINDLE AND BEARING COMPLETE

To set the propellers in place turn the frame upside down on your bench or table and put the hooked ends of the spindles through the holes in the angle plate and push the bearings through the holes until the collars stop them as shown in Fig. 38. To make them run easy put a drop of clock oil on each spindle.

*The Rubber-Strand Motor.*—You have yet one more thing to do to complete your model. Get two *strands* of flat, *para rubber*[1] ⅛ inch wide and 7 yards long. Dealers in model aeroplane supplies keep all kinds of rubber strands in stock and in any lengths you want for making *rubber motors.*

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[1] The Ideal Airplane and Supply Co. carry it in stock.

Take one of the strands and tie the ends together making a long loop of it. Double the loop back on itself twice until you have a *skein* of eight strands; now loop one end of the skein to a hook of one of the propeller spindles and then do the same with the other strand.

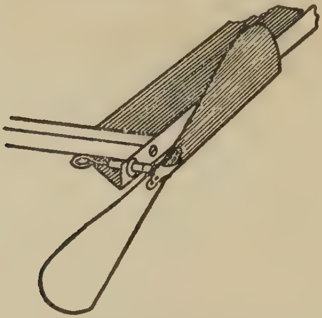

Fig. 38.—The Propeller Set in Place in the Angle Plate

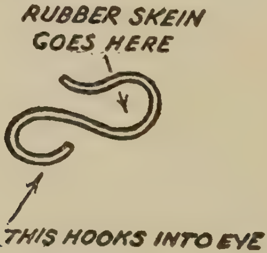

Fig. 39.—S Hook for Holding End of Rubber Skein and to Hook in Eye on Tip of the Flier. (Full Size.)

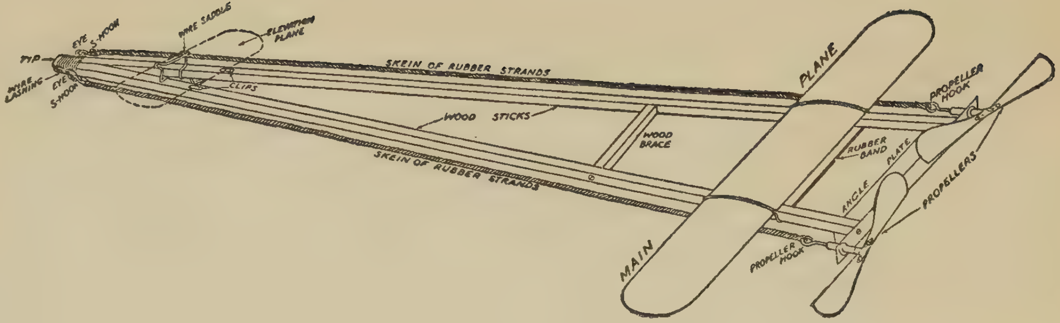

FIG. 40.— THE FLIER ASSEMBLED AND READY TO FLY

Make two S hooks of 3/64 inch iron wire like the one shown in Fig. 39 and slip an end of one of the skeins on a hook and then fasten the hook to an eye at the tip of the flyer. Do thou likewise with the other skein, all of which is shown in Fig. 40. If the air is calm and the day is nice take the flier out-doors for you are all ready to fly it.

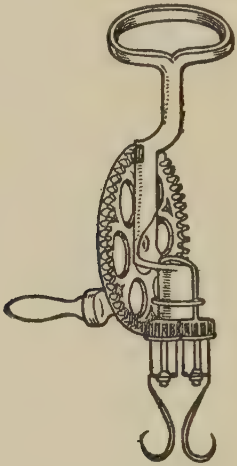

FIG. 41.—A WINDER MADE OF AN EGG BEATER

*How to Make the Motor Mote.*—Which means how to twist the rubber skeins and so store up power in them.

Where two propellers are used on a flier both skeins of rubber must be twisted up the same number of times or the flight of the flier will be lop-sided. An easy way to wind up the skeins is to use a *winder* and there are several kinds of these devices on the market.

You can make a pretty good one of a *Dover egg beater* by taking off all the parts from the gears down and fastening two hooks to the gears as shown in Fig. 41.

It takes a couple of fellows to *energize* the motor — that is to wind it up. Have some one hold the flier by the angle-plate as shown in Fig. 42 with his fingers over the propeller blades to keep them from turning. Take the S hooks with the skeins on them from the eyes on the tip and slip them on to the hooks of the winder.

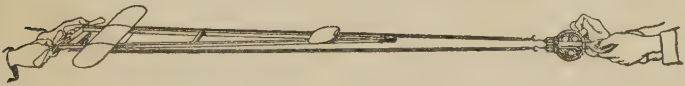

FIG. 42.— HOW TO ENERGIZE THE MOTOR

Now stretch the rubber skeins until they are about 6 feet long, as shown in Fig. 42, and then begin to wind and keep right on winding until each skein is twisted 125 to 150 times. As you wind the skein will get shorter and shorter until, by the time you have made the last twist in it, it will be about the same length as it was in the first place.

When you have wound up the rubber motor take the S hooks off of the hooks of the winder and slip them into the eyes on the tip of the flier.

*How to Fly the Flier.*— Take the flier from the fellow helping you and hold the angle plate and propellers with one hand and the brace with the other hand.

The *crucial* moment has come. Raise the flier just as though you were taking aim at a woogly bird in a wampus tree with a gun (see Fig. 43), and give it a slight shove into the air in the direction the wind is blowing when it soars like an eagle on the wing for a thousand feet or less. It's a beautiful sight.

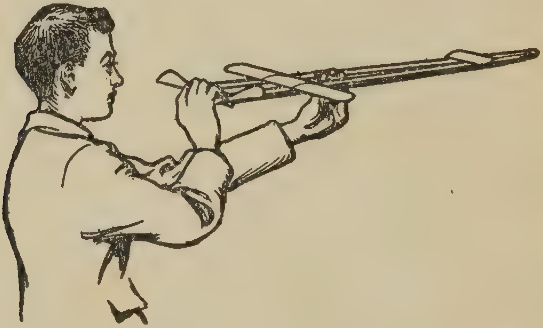

FIG. 43.—READY FOR A STRAIGHTAWAY FLIGHT

*How to Adjust the Flier.*—Should the flier take a header toward the ground, slide the main plane forward; but if it should have a tendency to shoot like a sky-rocket slide the main plane aft.

To make the flier fly straight away and to get the longest possible distance out of it both the elevation and main planes must be perfectly balanced and set in the right position and these things you will have to try out for yourself. A picture of the flier in full flight is shown at the end of this chapter.

THE SIMPLE FLIER IN THE AIR

## CHAPTER V

# MAKING A BLÉRIOT MONOPLANE

To build a model airplane to *scale* so that it will fly takes time and patience plus, but when you have fashioned one with your own hands and you see it soaring like a great bird through the air you will feel that you are just a little more than a human boy.

In making your first model of a big machine it is a good idea to start out with a *monoplane,* that is an airplane that has a single main plane, or wing. This type of machine came after the *biplane,* as an airplane having a pair of main planes, one over the other is called, but as a monoplane is somewhat more simple you'd better begin with it.

Now Blériot (pronounced *Blá-re-o*), a Frenchman, was the first aviator (pronounced *a-ve-á-tor*) to make the monoplane famous and the way he did it was by flying in one over the English Channel. He started from Calais, on the coast of France in the early morning of July 25, 1909, and without even a compass to guide him he flew at the rate of 40 miles an hour to Deal on the coast of England, where he landed hard, but though his machine was somewhat damaged, Blériot was not hurt.

**The Parts of the Model.**— This is the record-breaking monoplane, then, of which you will build a 3 foot model to scale and like its big prototype it is made up of six separate parts as follows:

(1) The *fuselage,* or body, of the machine.
(2) The *chassis* (pronounced *chaś-e*), or running gear.
(3) The *main plane,* or lifting wings.
(4) The auxiliary planes which in this model include (a) the *rudder* and (b) the *elevation plane.*
(5) The *rubber-strand motor,* and
(6) The *propeller.*

*The Tools You Need.*— Before you start to build your model get these tools: (1) a good sharp *pocket knife;* (2) a small *hand drill stock* (it costs about a quarter) with a couple of No. 60 *twist drills;* (3) a *jeweler's screw driver* (10 cents); (4) a pair of 4 or 5 inch *flat nose side cutting pliers* and (5) either a *jeweler's hammer,* or the smallest machinist's hammer you can get.

*Materials for the Fuselage.*— Also get these materials: (1) one-half ounce of *thin brads* ½ an inch long and the same amount of brads ⅝ inch long; (2) a dozen round head *brass wood screws,* and (3) a small bottle of *liquid glue.*

You will also need (4) five *basswood sticks* 5/32 inch square and 31½ inches long — four of these are for the *beams,* that is, the long pieces for the fuselage and one to be sawed up for the stanchions, that is, the upright pieces, the *struts*, or cross pieces and the *standards*, or long uprights, and (5) a *birch stick* $5/16$ inch square and 31 inches long for the *motor beam* and the *cross-bar* for the propeller hanger.

**Making the Fuselage.**— As the fuselage is the backbone of the machine it must be made quite strong for not only are all the other parts fastened to it but the *rubber skein* which forms the motor is stretched between its ends.

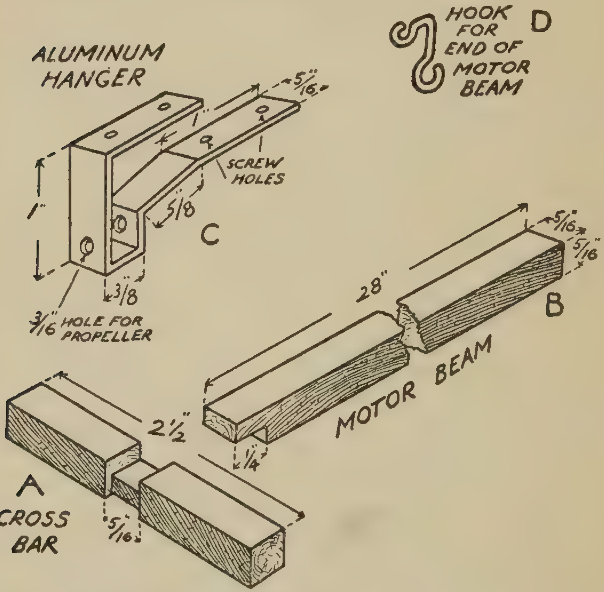

FIG. 44.— THE CROSS-BAR, BEAM AND ALUMINUM HANGER

Take a good look at the pictures that show the fuselage so that you will know exactly how it is put together and then go to work. The first thing to do is to make the *cross-bar* that supports the *hanger* for the *propeller shaft* as this fits in the fore end of the fuselage.

Cut off two pieces of the 5/16 inch birch stick and make one of them 2½ inches long and the other 28 inches long. Cut these sticks exactly as shown at A and B in Fig. 44, when the long stick which is the motor beam, that is the beam to which the rubber strands are secured, will fit snugly in and set up against the short piece, or cross-bar, and makes a lap joint.

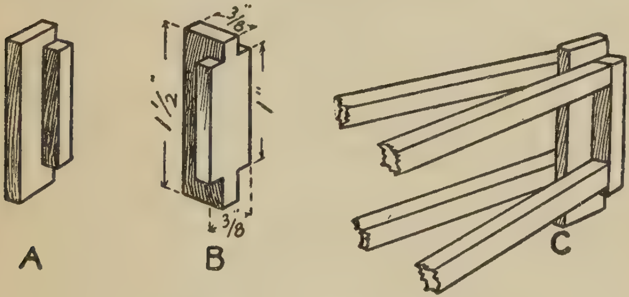

FIG. 45.—HOW THE STERN-POST IS MADE

This done, cut off another piece of the birch stick 1½ inches long and whittle it down until its shape is like that shown at A and B in Fig. 45. This is for the *stern-post* and the rear ends of the beams of the fuselage are fastened to it as shown at C.

Next cut four pieces from the 5/32 inch basswood sticks and have them 31½ inches long; these beams are for the frame of the fuselage. The rear ends of all the beams should be bent so that they *converge,* that is come together, at the stern-post as shown at A in the top plan view of the fuselage in Fig. 46. You don't have to bend the beams to make the fuselage but it will look more like a Bleriot if you do.

It is easy, though, to bend the beams, so don't let this little matter worry you. Take a smooth pine board about a foot wide and a couple feet long, mark out the shape of it and drive a row of small wire nails on the lines as shown at B. Take two of the beams, put the ends into the spout of a teakettle and let them boil for half an hour; at the end of this time take them out and you will find they will be very soft. You can now push them into the form made by the nails in the board; let them dry over night and when you remove them they will be bent and stay bent.

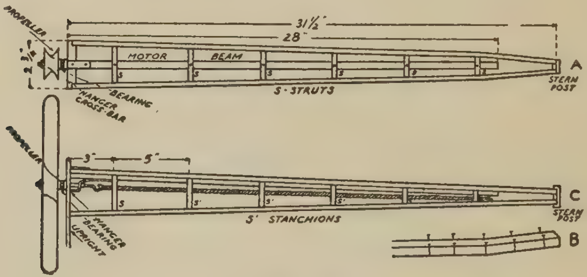

FIG. 46.— TOP AND SIDE VIEW OF THE FUSELAGE

Finally cut off two pieces of 5/16 inch basswood 6¼ inches long for the standards which not only hold the fuselage together on the sides but also serve to support the running gear as shown in the fore end view in Fig. 47, and a piece 2½ inches long for the strut for the fore end which is also shown in Fig. 47.

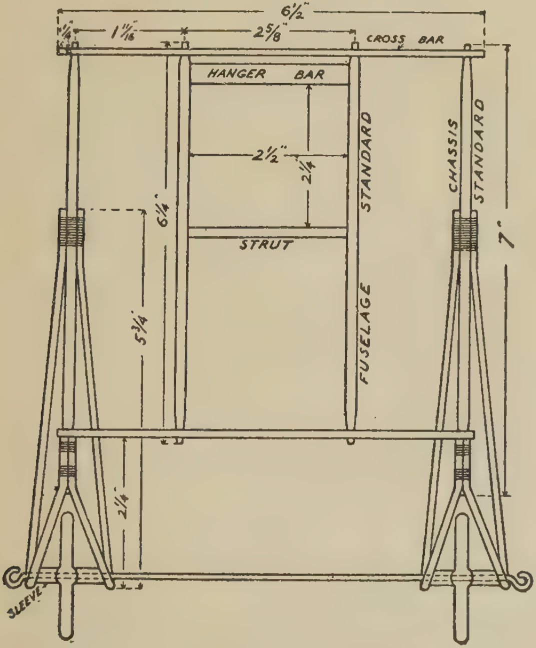

FIG. 47.—PLAN VIEW OF FORE END OF FUSELAGE AND RUNNING GEAR

Begin now to assemble the fuselage by gluing the hanger bar, the strut and the standards together to form the fore end and nailing them with beads. The opening made by these four sticks should be 2¼ inches high and 2½ inches wide as shown in Fig. 47.

Next glue and nail the straight ends of the beams to the fore end as shown at A and C in Fig. 46, and then fix the bent ends to the sternpost as shown in Fig. 45. This will make the beams come together within ⅛ inch at the top and bottom and ⅝ inch apart on each side.

Bracing the frame is the next thing in order. Cut off twelve 5⁄16 inch basswood sticks for the *struts* for the top and bottom. The first top and bottom struts should be set 3 inches from the fore end as shown at A in Fig. 46 and each succeeding strut should set 5 inches from the other. The *stanchions,* which are the side braces, are set the same distances apart as shown at C in Fig. 46. This completes the fuselage as shown in Fig. 48 and it will have very graceful lines.

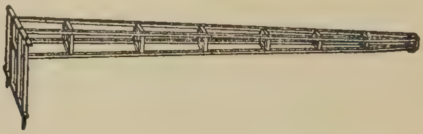

Fig. 48.— The Fuselage Complete

The motor beam is next in order, but before you put this in place make a hook of a bit of strong brass wire as shown at D in Fig. 44 and screw it to the rear end of the beam. Smear some glue on the other end of the beam, slip it inside of the fuselage and fit it into the cross-bar. To make it tight all the way along, glue and screw the top struts to the beam, and it's a good scheme to wire the beam and each strut it crosses together.

**The Hanger Propeller Shaft and Motor.**— The reason these parts of the airplane should be fitted in the fuselage at this time is because it can be done more easily than when the chassis and planes have been mounted on it.

Take the strip of aluminum, bore two 1/16 inch holes near each end and bend it as shown at C in Fig 44. After you have shaped it up, drill a 3/16 inch hole through the parallel pieces of the upper part for the bearing of the propeller shaft. Now screw the *hanger* to the hanger bar and to the motor beam as shown in Fig. 50.

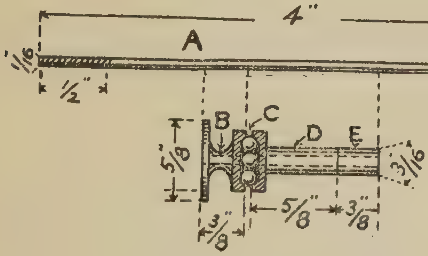

FIG. 49.— CONSTRUCTION OF THE PROPELLER SHAFT

Your next move is to get a *ball-bearing* propeller shaft and unless you have a lathe and know how to use it you had better buy it ready made. You can get one for 50 cents or can make one from the drawings shown in Figs. 49 and 50.

Cut threads on one end of the shaft A and screw a nut on it; solder the flange and ball bearing case, which is turned from a solid piece of brass, to the shaft 1¼ inches from the threaded end.

Now lay six ³⁄₃₂ inch steel balls in the *race,* that is the groove of the ball-bearing case, which is turned on the end of the bearing D, over the end of the shaft and on which it turns freely. Slip the brass sleeve E over the shaft and against the bearing and solder it there when your ball-bearing propeller shaft is done.

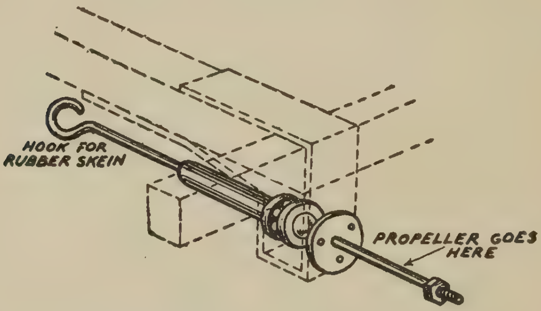

FIG. 50.—THE SHAFT AND BEARINGS IN THE ALUMINUM HANGER

To mount the propeller shaft in the fuselage all you have to do is to slip the sleeve through the holes in the aluminum hanger and bend a hook on the end of the shaft.

**The Rubber-Strand Motor.**— You are ready now to install the motor. Buy a strand of ⅛ inch square rubber about 12 feet long (it costs 5 cents a foot) and tie the ends together in a hard knot. Double the loop so made back on itself to two-thirds of its length and then double the short end over when you will have three loops, or six strands, each of which is 2 feet long. Slip one end of the loops over the hook on the aft end of the motor beam, stretch it a little and then slip the other end of the loops over the hook on the propeller shaft.

**Putting on the Chassis.**— You will need this list of materials for the running gear: (1) two basswood cross-bars 3/32 inch thick, ¼ inch wide and 6½ inches long; (2) two standards ⅛ inch square and 7 inches long; (3) four pieces of rattan, or reed, as it is called, ⅛ inch in diameter and 10¼ inches long; (4) four pieces of rattan 7½ inches long; (5) a pair of rubber tire wheels[1] 2 inches in diameter and mounted on a

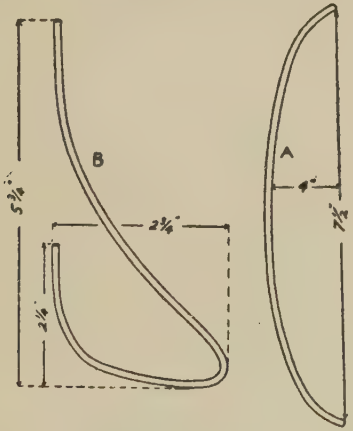

FIG. 51.— SHAPE OF THE RATTAN SHOCK ABSORBER HANGER AND BRACE

steel wire shaft 7½ inches long; (6) a piece of rattan 9 inches long, and (7) a spool of 50 feet of No. 32 iron wire.

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[1] Pneumatic rubber-tired wheels make the model look like the big machine and they cost about 60 cents a pair. If you

Drill a 3/32 inch hole, ¼ inch from each end of each cross-bar and the same size hole 1 1/16 inch in from each of the end holes as shown in the front view of the fuselage and chassis, Fig. 47. Smear the rounded ends of the fuselage and the chassis standards with glue and force them through the holes in the cross-bars to form a frame for the chassis.

While this is drying, draw four outlines of the form shown at A in Fig. 51, and from the outlines of the form shown at B, on your large pine board, but of the sizes marked on them, and drive a double row of nails ⅛ inch apart on the lines. Put the pieces of rattan in a tea-kettle of water and let it boil for 15 minutes and then you can slip them easily between the rows of nails to give them the right shape.

When the pieces of rattan are thoroughly dry take them out of the forms and bore a hole in each end of each one; screw the long ends of the bent four hangers to the sides of the chassis standards of the frame so that the lower ends will set up against the lower cross-bar as shown in Fig. 52 and bind them with the iron wire. This done fasten the bent lengths of rattan to the opposite sides of the lower beams of the fuselage and to each of the rattan shock absorbers.

Next make an *eye* on a piece of steel wire 1/16 inch

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want something cheaper you can buy wooden wheels or stamped tin wheels for 10 cents a pair or you can make them yourself.

in diameter and 8½ inches long, make four sleeves of ¹⁄₁₆ inch, inside diameter, aluminum tube, ½ an inch long, and slip one of these on the wire shaft down to the eye; now slip on a wheel, put on two more sleeves, then a wheel, next another sleeve and lastly bend another eye on the end of the wire to keep all these parts on it as shown in Fig. 52.

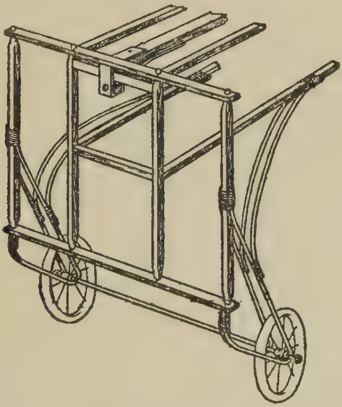


Fig. 52.— Perspective View Fore End of the Fuselage and Chassis

Set the wire shaft in the shock absorbers with the wheels in the middle of them and so that they can't slip by the sleeves. Wire the bends of the shock absorbers to the shaft to keep them in place and the chassis is done.

**Making the Rudder.**— To make the rudder, cut off a round stick ³⁄₃₂ inch in diameter and 2½ inches long for the shaft and a ⅛ inch stick 2 inches long for the tiller bar. Also get a piece of rattan 3/32 inch in diameter and 12½ inches long.

Steam the pieces of rattan and bend them to the shape shown in Fig. 53, by making a form of nails driven in a board as explained before and when these are dry drill a hole in each end and wire them to the rudder shaft. At the middle of the shaft fasten them to the tiller bar with wire. Cover the rudder on both sides with bamboo paper or silk and varnish them and then fasten the rudder to the sternpost with wire.

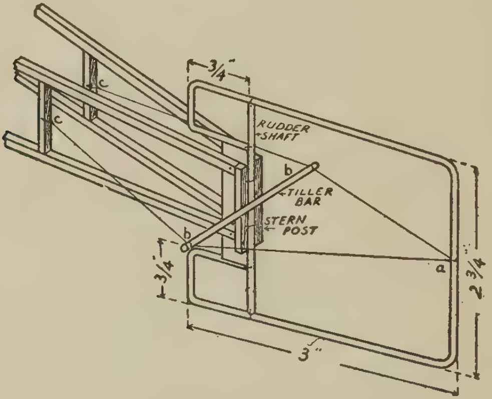


FIG. 53.— THE RUDDER CONSTRUCTION

Now guy out the rudder with fine wire by twisting a piece about 12 inches long around the middle of the rudder at a, looping it around on the tiller bar at b and then fastening the ends of the wire to the stanchions at c. Tighten these wires up until the rudder is exactly in line with the center of the fuselage.

**The Elevation Plane.**— This is a small cambered plane that sets aft and under the fuselage and not only gives the model its fore and aft stability but its sidewise balance as well.

To make it you will need (1) two pieces of rattan ⅛ inch in diameter and 21 inches long for the frame; (2) two pieces of basswood ⅛ inch square and 16 inches long for the spars; (3) four pieces of basswood ⅛ inch square and 4½ inches long for the ribs, and (4) a piece of wood ⅜ inch thick and 5½ inches long for a bar to strengthen the joint in the leading edge of wing.

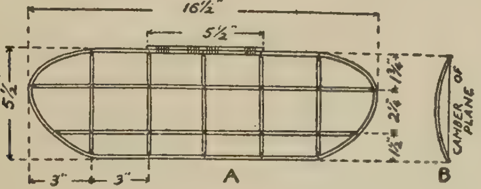


FIG. 54.— THE FRAME OF THE ELEVATION PLANE

The first thing to do is to shape the pieces of rattan into the frame. To do this draw the outline of an oval on your pine board, make it 5½ inches across and 16 inches long and have it conform to the outline of the plane as shown at A in Fig. 54. Next drive a line of nails on the oval outline and ⅛ inch inside of it drive another line of nails.

This done, boil or steam the pieces of rattan, bend them and put them in the form of nails. When dry take them out and whittle down the ends to make split joints. Wire the two halves of the frame together, then lay the wood bar on the joint of the leading edge and wire it on tight, when the frame will be as strong as though it was made of a single piece of rattan.

The camber of the plane is shown at B and the ribs, as you will see, make a smooth curve. Take the five short strips of wood and bend them to the shape shown by steaming them and putting them in the form. When dry, drill a hole in each end of each rib and also drill holes in the opposite sides of the rattan frame at distances about 3 inches apart.

Wire the ends of the ribs to the frame and then drill holes in the ends of the spars and in the opposite ends of the frame so that the long spar will set 1¾ inches from the leading edge and the short spar will be 1½ inches from the trailing edge. Now lay the spars on *top* of the ribs and wire the ends of the former to the frame; finally drill holes through the spars and ribs where they cross and wire them together. This construction will make a strong plane.

To finish this plane cover it on both sides with bamboo paper, or silk, and glue the edges carefully over the frame to make a nice smooth job of it and whatever else you do be sure that the concave surface, that is, the under side, is perfectly smooth.

The next and last thing to do, as far as this plane is concerned, is to secure it to the fuselage. Turn the latter upside down; lay the plane with its *convex,* that is its rounded side, against it so that its trailing edge will come to within 1 inch of the sternpost; this will bring the long span of the plane on the strut of the fuselage and then nail and wire them together.

**Making the Main Plane.**— This is quite a big fellow but you will have no trouble in making it after you have gotten all the pieces together.

(1) Get two pieces of ⅛ inch round rattan each of which is 31 inches long; (2) cut off a ⅛ inch square stick for the leading edge 26 inches long or join two sticks together to make one of this length; (3) cut off two sticks for the spars and make one of them 34½ inches long and the other one 31 inches long; (4) cut off eight ⅛ inch sticks of wood each of which is 8 inches long for the ribs and (5) make an aluminum sleeve ⅛ inch in diameter and 1 inch long, all of which are shown in Fig. 55.

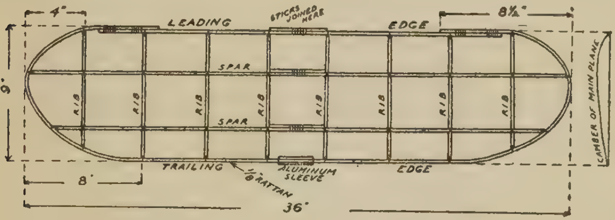


FIG. 55.— THE FRAME OF THE MAIN PLANE

Begin by making eight forms by driving nails in a a board and give them the shape of the rib shown in Fig. 56. Boil or steam the sticks, put them in the forms and let them stay there over night. Bend the pieces of rattan in the same fashion to the shape shown in Fig. 55.

The next day put each half of the plane together by drilling holes in the ends of the ribs and spars and around the frame and wiring them fast as well as wiring the ribs and spars up as shown in Fig. 55. Now cover each half of the plane with bamboo paper or silk but do not let the covering extend beyond the inside ribs.

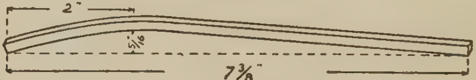


FIG. 56.—THE SHAPE OF THE RIBS

When the plane is dry slip the projecting ends of each half of the entering edge under the upper beams of the fuselage as shown in Fig. 57, and just in front of the first strut. Lap the fore ends of each half plane and bind them together with wire and then bind them with wire to the strut.

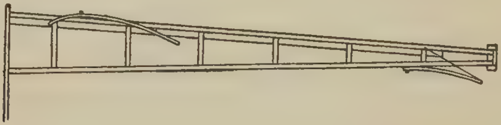


FIG. 57.—SIDE VIEW OF THE FUSELAGE SHOWING THE MAIN AND ELEVATOR PLANES

Bring the ends of the first spar together *over* the upper beams and wire them together; then slip the ends of the second spar under the upper beams and likewise wire them together; finally set the ends of the trailing edge *under* the motor beam and slip the aluminum

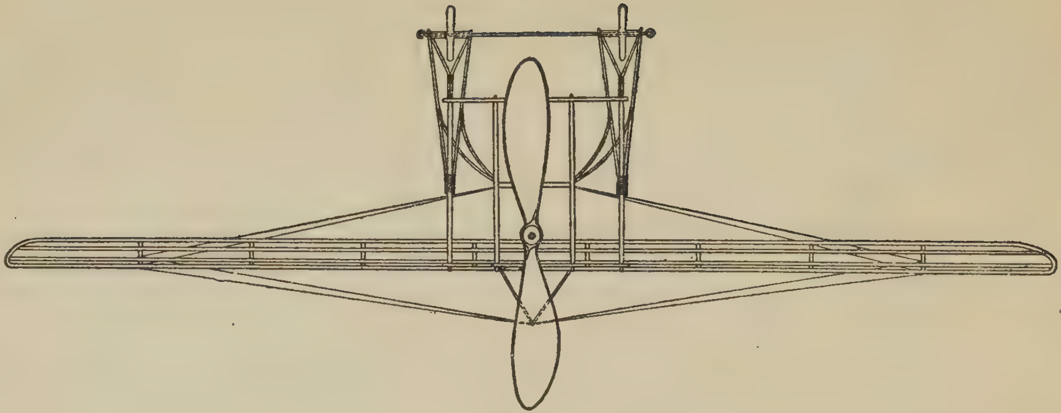


FIG. 58.— FRONT END ELEVATION OF THE MODEL WITH THE PLANE IN PLACE

sleeve over them. Fig. 58 shows how the plane sets on the fuselage.

When you have done these several little things the inside ribs of the main plane will set up close to the upper beams of the fuselage and the plane will be held rigidly in place at the proper angle to make the model fly well.

The tips of the plane must, however, be further supported to stand up under the strains and stresses of flight and this is done by making a bridge of 3/32 inch thick aluminum wire. Cut off two pieces of wire 8 inches long, bend them to form a V and put eyes on their ends and screw each one to the upper beams of the fuselage exactly over the middle of the main plane.

Bend them until their tips meet and then fasten four No. 25 steel or brass wires about 16 inches long to the top of the bridge and over each pair of wires slip a little aluminum sleeve. Next screw four of the smallest screweyes into the ends of the spars where they cross the end ribs; thread the ends of the wires through the eyes and when you have the plane perfectly true twist up the wires tight. When you do this be sure that the plane is drawn up taut but no farther.

Screw four more screweyes in the spars and ribs on the under side of the plane and screw two screws into the lower beams of the fuselage directly under the apex or point of the inverted V bridge. Fasten four more lengths of steel or brass wire to the eyes in the lower beams — two wires to each eye — put a sleeve on each pair and secure them to the screw eyes in the tips of the plane.

You can easily get any adjustment of tension you want on either half of the plane making it higher or lower by simply sliding the sleeves up and down on the wires.

*Covering the Fuselage.*— Cut out four strips of bamboo paper, about ¼ inch wider than the top, bottom and sides of the fuselage and long enough to cover the first four panels, that is, the distance from the fore end of the fuselage to the third set of struts and stanchions. When dry, coat the paper or silk with shellac or varnish.

**Putting on the Propeller.**— As the Blériot model is a heavy one and uses only a single propeller, it must be designed so that it will be light and strong and have a *pitch*[2] that will give the greatest *thrust* with the least expenditure of power when it will drive the machine the longest possible distance.

The propeller for this model should measure 12 inches from tip to tip. The best kind of a propeller to use with a Blériot model is made of poplar and you can buy one ready made (see Fig. 59), for about $1.00.

There are a lot of fellows who can cut out a propeller with a pocket knife which will have all the driving qualities of those carved out by experts and if you want to try your hand and make your own propeller you will find out just how to do it in Chapter VII.

[2] The *pitch* and *thrust* of propellers are fully described on page 150.

But if you have never made a scale model of an airplane, my advice is to buy a ready-to-use propeller and then your bright lexicon of youth will have no such word as fail when you come to flying your model.

Slip the propeller over the end of the shaft, put on a washer and screw on a nut; then screw the flange of the ball-bearing cup to the back of the propeller and you are ready for the *crucial test* as the high-brows say. The plate following this chapter shows the little machine making its initial flight.

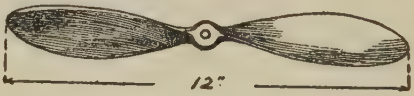


FIG. 59.— THE PROPELLER

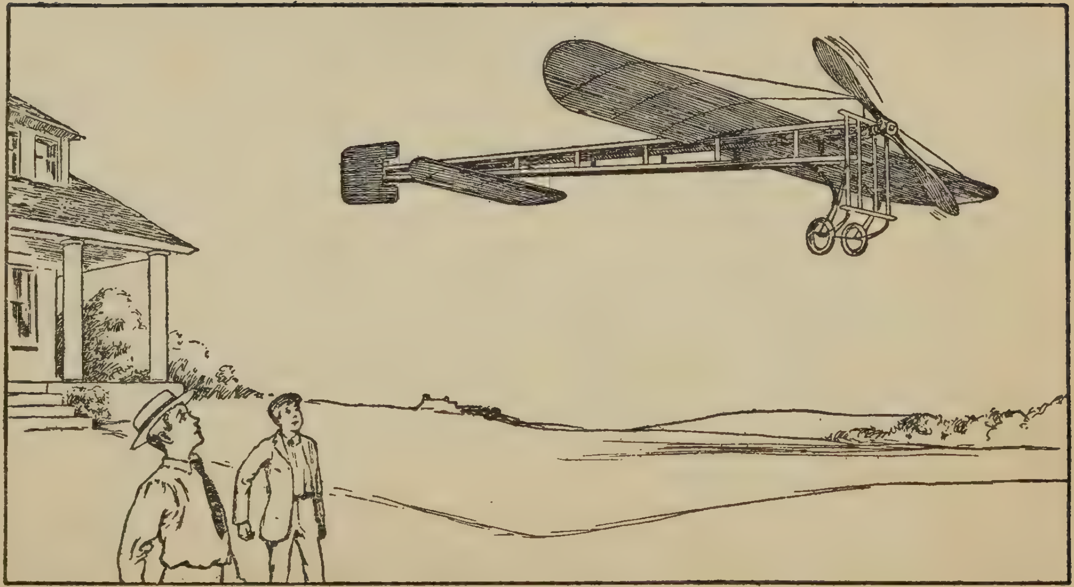
**Flying the Model.**— To make the model fly well, see that the tips of the plane are perfectly even, that the rudder is straight and that the elevation plane sets true.

Put the model on a stretch of smooth and level ground and hold the top of the fuselage with your left hand; wind up the rubber motor by turning the propeller about 150 times, in the direction that the hands of a clock move, with your right hand. When you have wound it up grip the tip of the sternpost with your left hands and lift the after end of the fuselage up and clean off of the ground.

Now let go of the propeller and at the same time give it a gentle push ahead, when it will run along, rise in the air and fly as gracefully as the big machine it was built after, as you will see from the picture that follows this chapter.

If when the model is in flight, it should dip to either side, it shows that the tips of the plane are uneven and you must true them up with the guy wires. As the elevation plane controls the up and down movements of the airplane, if it has a tendency to dive pull the trailing edge of the elevation plane up, but if it should climb like a skyrocket let the trailing edge down.

To make the model fly in a circle set the rudder at a slight angle and your wish will come true.



Bleriot Model in Flight

## CHAPTER VI

# MAKING A WRIGHT BIPLANE

This is a model of the famous airplane invented, built and used by the Wright Brothers when they electrified the world with their first miracles of man-flight.

Their machine is very different from the monoplane just described for there are two main planes, one of which sets above the other and for this reason it is called a *biplane*. The elevator planes are placed in front of the main planes, and, finally, it has two propellers back of the main plane and these *push* the machine ahead like the screws of a boat instead of *pulling* it like an engine hauling a train.

The design, too, is very different from that of a monoplane in that it has no fuselage, or body but it gets there just the same and even a little better in the early days.

**The Parts of a Biplane.**— Before beginning to make this machine, read the preceding chapter on the Blériot monoplane as many details of construction are given there that are not repeated here.

While this plane looks to be more complicated than the Blériot monoplane and it has about a dozen more separate pieces, still it has the same number of distinct parts and these are:

(1) The main planes.
(2) The chassis.
(3) The motor frame.
(4) The elevation planes.
(5) The rudders.
(6) The propellers.

**What to Get First.**— Get all of the tools cited for building a monoplane (see page 73), besides a 1/16 inch and a 1/8 inch twist drill; and get the brads, glue and wire, too.

You will need for the planes (1) four sticks of basswood 1/8 inch thick, 1/4 inch wide and 36 inches long for the spars; (2) two pieces of rattan 1/8 inch in diameter and 46½ inches long (it is sold in 6 foot lengths) for the sides and rear edges of the planes; (3) five basswood sticks 1/8 inch thick and 3/16 inch wide for the ribs; (4) four basswood sticks 3/32 inch square, or, better, 1/8 inch in diameter and each about 20 inches long for the stanchions; (5) a strip of aluminum No. 30 gauge (or use very thin tin) 3/8 inch wide and 2 inches long for the *sleeves;* (6) 36½ inches of Japanese silk, and (7) four ounces of collodion for waterproofing the silk after it is glued to the planes.

There are a lot of other things you will need but these will be listed in the order in which they are used.

**Building up the Plane-Cell.**— After the two planes are joined together they form what is called a *plane-cell.* The first thing to do is to make a form of wire nails driven in a pine board as described on page 85 and steam or soak the rattan reeds in boiling water until they are soft and then bend them to the shape shown in Fig. 60.

Next cut off fourteen pieces of the 3/32 inch square basswood stick into 2⅛ inch lengths and steam or soak these in hot water. Make three or four forms of nails driven in a board exactly like the side view of the rib shown in Fig. 61 to fit; bend the softened pieces of wood into the nail form and let them dry over night.

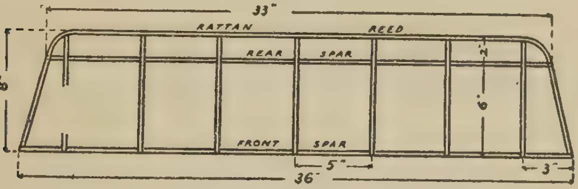


Fig. 60.— Top View of the Main Plane

Take the ⅛ x ¼ sticks and cut two of them off 36 inches long and make the other two 33 inches long. With your smallest drill make holes in the ends of the spars and in the ends of the rattan reeds and fasten them together with glue and wire as shown in Figs. 61 and 62.

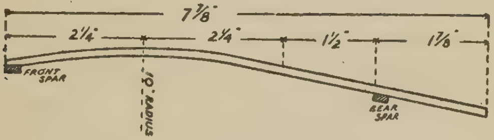


Fig. 61.— Side View of the Rib

The next thing is to take each rib and cut off the tip of the curved end so that it will lay flat on the front spar and drill holes in the ends of all of them. Drill a hole 3 inches from each end of both of the front spars and then drill six holes in between and have them exactly 5 inches apart.

Fasten the curved ends of the ribs to the front spar with glue and wire; now drill holes through each rib and the rear spar and secure these in the same way and be careful that the ribs are parallel with each other. Finally pass a wire through the back end of each rib and wire it to the rattan edge of the plane.

Next drill a ⅛ inch hole 2 inches from each end of the front spars, another hole 5 inches from the first one and still another 6½ inches from the second hole. Start from the other ends of the spars and drill the same number of holes toward the middle. This makes the two holes in the middle 9 inches apart. Drill six holes in each of the rear spars and have these holes in a line with the holes in the front spars. The positions and distances of these holes which are for the stanchions are shown in Fig. 62.

For the stanchions cut off twelve 5/32 inch square or ⅛ inch round sticks into lengths of 7 3/16 inches each. If you use square sticks whittle down the ends so that they will fit snugly into the holes in the spars, but if you use round sticks they will fit in as they are.

The frames must be covered now and to do this, cut two strips of the Japanese silk 8½ inches wide and 36½ inches long; smear glue on top of the ribs, the front edge of the front spar and the top of the rattan trailing edge. Lay the silk on top of the plane, stretch it over and press it down until it is as smooth and tight as you can get it. When it is dry, turn the plane over and glue the silk down to the under side of the spar and rattan and trim off the edges. Brush it over with collodion and when it is dry, the silk will be as tight as a drumhead. Cover the other frame the same way.

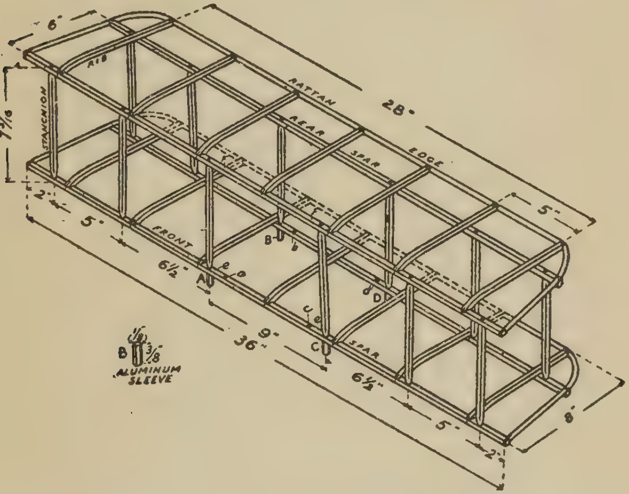


Fig. 62.—The Main Planes Complete

Now glue and set the stanchions in the holes of one of the planes with the *cambered,* that is the hollowed part down; then set the upper ends of the stanchions in the holes of the top plane so that its cambered surface is down and see to it that the top and bottom planes are exactly the same distance apart all around. When you have done this your plane-cell is finished.

Make four *sleeves,* or tubes, of very thin tin, or better, aluminum; cut out four pieces of metal and make each of them ⅜ inch wide and ½ an inch long and roll them into little tubes as shown at B in Fig. 62. Let these four sleeves into the holes in the spars marked A, B, C, and D by slipping them over the ends of the stanchions ⅛ inch and leaving ¼ inch of the ends of the sleeves projecting below the spars. These sleeves are to take in the ends of the V-braces of the chassis and we're up to that part of the model now.

**Making the Chassis.**— At first glance this part looks rather complicated but if you will go over Fig. 63 carefully you will see that it can be made very easily.

The materials needed for the chassis are (1) a stick of basswood 3/32 inch thick, ¼ inch wide and 6½ inches long for the struts; (2) two pieces of rattan ⅛ inch in diameter and 28 inches long for the *runners;* (3) two pieces of ⅛ inch rattan and 12 inches long for the U-braces; (4) two pieces of ⅛ inch rattan 6 inches long for the rear braces; (5) two pieces of ⅛ inch rattan 15 inches long, for the horizontal braces; (6) one piece of rattan 8 inches long for the reed strut on the runners; (7) a stick 3/32 inch square, or ⅛ inch round, and 20 inches long for the stanchions; (8) three rubber-tired, wire-spoked wheels 1½ inches in diameter, and (9) a straight iron or aluminum wire 1/16 inch in diameter and 45 inches long for the axles and axle braces.

Begin by making the struts of 3/32 x 1/4 inch stick and cut off two of them 8 inches long and the other one 8¼ inches long. Drill two ⅛ inch holes, 1 inch from the ends of the two shortest struts for the stanchions. In the other strut which is for the front one, drill four ⅛ inch holes and have two of them ⅜ of an inch from the ends and drill the other two holes 1¾ inches from the ends; this makes the inside holes 5½ inches apart and into them go the ends of the *shafts* of the elevation planes. The outside holes are 7½ inches apart and these take in the ends of the *runners*.

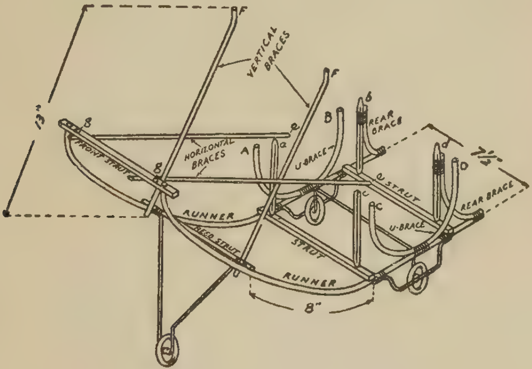


Fig. 63.— The Chassis

Having cut and drilled the struts, take the 28-inch rattan reeds and bend them into runners in a form of nails to the shape shown in Fig. 64. When the runners are dry, glue the bent ends in the outside holes of the long strut; wire one of the short struts 2 inches from the rear ends of the rattan and the third strut 8 inches from the rear ends as shown in Figs. 63 and 64.

Cut the 3/32 inch square or 1/8 inch round stick into four 5-inch lengths for the stanchions and glue and set the ends of these into the holes in the struts. This done, take the two 12-inch reeds of rattan and steam and bend them into the U-shape shown in Fig. 64, and wire these to the runners between the two rear struts. Make the rear braces by steaming and bending the 6-inch lengths of rattan into the shape also shown in Fig. 64, and wire an end of each brace to a rear stanchion and the other end to the end of a runner as shown in Fig. 63.

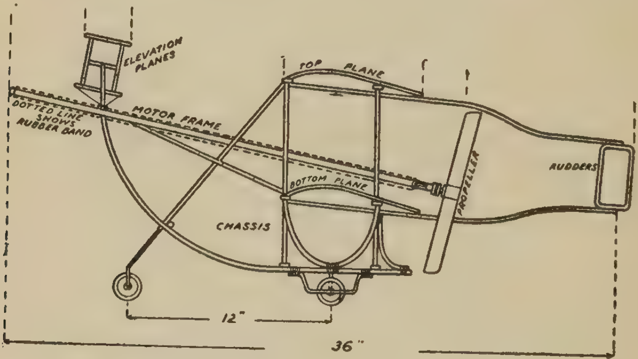


Fig. 64.—A Side Elevation of the Biplane

Set the ends of the two horizontal rattan reeds under the front strut and just inside the runners and wire them there leaving the other ends free for the time being. Across the runners and half way between the front and middle struts wire the rattan strut to the runners; to the ends of this strut and inside of the runners wire on the vertical braces which should have the upper ends bent as shown in Fig. 63. This completes the frame-work of the chassis and all that remains to be done is to put on the wheels.

Any kind of wheels can be used but the spoked wheels make the most classy appearance. For the axle and support for the front wheel cut off a piece of the 1/16 inch wire 10 inches long. Put the wheel in the middle of the wire and a round steel head on each side of it, bend the wire as shown in A and B in Fig. 65 and then fasten the ends to the reed strut with fine wire.

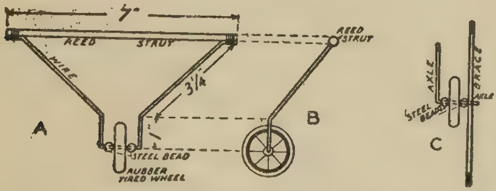


FIG. 65.— DETAILS OF THE AXLE CONSTRUCTION

For the axle of the rear wheels use a piece of the 1/16 inch steel wire 10½ inches long, and bend it as shown at B in Fig. 65; slip a steel bead on each end, put on a wheel and slip a steel bead over it. For the axle braces cut off two pieces of 1/16 inch wire 4½ inches long; hammer the middle of each piece of wire flat and drill a 1/16 hole through the flat part. Slip an end of the axle through the hole in each brace and solder it there. Wire the axle and the ends of the axle brace to the runners as shown in Fig. 65 and your running gear is done.

**Mounting the Plane-Cell on the Chassis.**— And now comes the job of setting the planes on the chassis. If you will turn back and look at Fig. 62, you will see that the four tin, or aluminum sleeves are lettered capital *A, B, C,* and *D* and that the four ⅛ inch holes in the spars are lettered in *lower case a, b, c,* and *d;* by referring to Fig. 63 you will also see that the ends of the U-braces are lettered *A, B, C,* and *D* and that the ends of the stanchions are lettered *a, b, c,* and *d.* Now the U-braces of the chassis *A, B, C,* and *D* fit into the sleeves *A, B, C,* and *D* of the main planes, while the stanchions *a, b, c,* and *d* fit into the holes *a, b, c,* and *d* of the spars of the lower plane.

When you have glued the braces and the stanchions of the chassis to the spars of the plane, drill holes in the ends *ee* of the *horizontal* braces (see Fig. 63), and wire them to the front spar of the lower plane at the places marked *ee* (see Fig. 62). Finally wire the ends *FF* of the vertical braces (see Fig. 63), to the front spar of the upper plane at *FF* (see Fig. 62). How the chassis and plane-cell look when they are put together, is shown in Fig. 64.

**The Motor Frame and Motor.**— The motor frame holds the rubber skeins which develop the motive power, the propeller bearings and the propellers. To make the frame take a basswood stick ¼ inch square and cut off the following lengths: (1) two sticks for the sides or beams, 26 inches long; (2) one cross-bar for the front, 10 inches long; (3) one strut 7¾ inches long and one cross-bar for the rear, 12 inches long. Drill a ⅛ inch hole ½ an inch from each end of the rear cross stick for the propeller bearings; glue and nail it to the ends of the beams so that the latter will be exactly 8¼ inches apart as shown in Fig. 66 and glue and nail the strut half way between the ends of the beams.

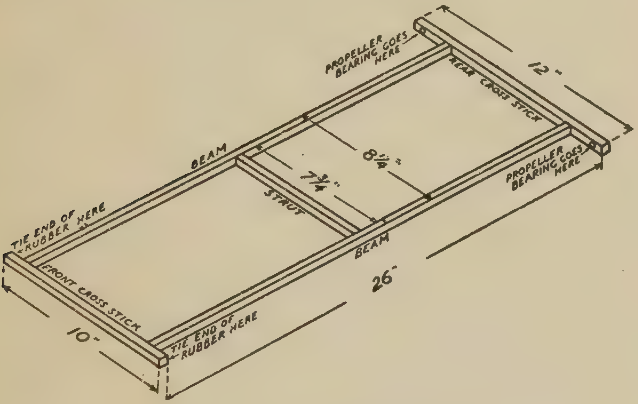


FIG. 66.—THE MOTOR FRAME

Now before you fasten on the front cross-bar to the frame, push the latter between the planes from the back and inside of the stanchions AB and CD (see Fig. 62); bring the ends of the beams under the ends of the front strut of the chassis and outside of the vertical braces, as shown in Figs. 63 and 70 and let the ends of the beams project 5 inches in front of the strut and glue and nail the beams to the strut.

To further brace the frame glue and screw the beams to the four stanchions A, B, C, and D so that the rear end of the frame is 2 inches above the lower plane as shown in the side elevation Fig. 64. Put on the front cross-bar now and you're ready to install the motor.

*The Motor.*— You want two ball-bearing propeller shafts and bearings of the kind described for the Blériot monoplane. Working drawings for these shafts and bearings are given in Fig. 49 and the way they are mounted is shown in Fig. 50 while you will find all the information you want about them on pages 79 and 80. Push the bearings through the holes in the ends of the rear cross-bar and bend a hook on the end of each shaft.

Get 44 feet of ⅛ inch square rubber strand and cut it in two. Take each strand and make a skein of seven loops; the easiest way to do this is to drive a couple of nails 26 inches apart in a board, hold one end fast and wind the strand around the nails; when it is all wound on, tie the ends of the rubber in a hard knot.

Take the skein from the nails, loop one of the ends over an end of the front cross-bar of the frame and tie it there with a bit of string; then loop the other end in the hook of the propeller shaft. Do the same thing with the other strand of rubber and you've got *some* motor.

**Forming the Elevator Planes**— The elevator planes are placed in front of the biplane and the frame on which they rest is *pivoted* so that the planes can be tilted up or down and by means of which you can get the angle of flight you want.

To make the plane-cell get (1) two reeds of rattan ⅛ inch in diameter and 28 inches long for the edging of the planes; (2) a stick 3⁄32 inch thick, ¼ inch wide and 24 inches long for the top and bottom bars of the H frames; (3) a stick ⅛ inch square and 10 inches long for the struts and guide bars; (4) a stick 3⁄32 inch square, or ⅛ inch round wood 24 inches long for the four uprights; (5) a stick ⅛ inch thick, 3⁄16 inch wide and 24 inches long for the shafts and the middle bars they are pivoted to, and (6) silk enough to cover them which you will have left over from the main planes.

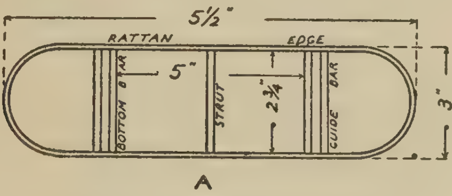
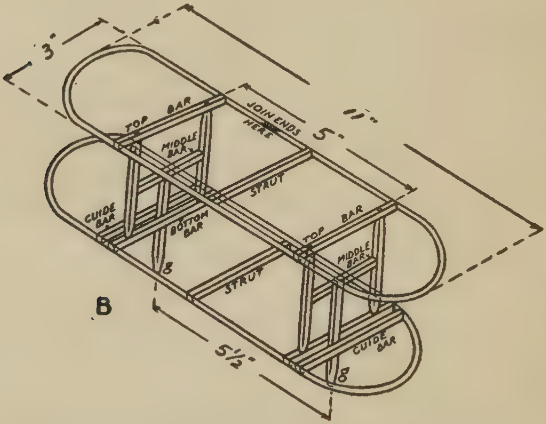


FIG. 67A.— THE ELEVATOR PLANE

Begin by steaming and bending the rattan exactly to the size and shape shown in Fig. 67A and join the ends of each reed *flush* by beveling them and wrapping them with wire. When the reeds are formed, cut off four pieces of 3⁄32 by ¼ inch sticks 2¾ inches long for the top and bottom bars of the H frames and drill a ⅛ inch hole in the end of each bar ½ an inch from each end.

Glue and wire these bars to the frames flush with them and exactly 5 inches apart. Cut off four pieces from the ⅛ inch square stick each of which is 2¾ inches long for the struts and the guide-bars; glue and wire the struts to the middle of the upper and lower planes and then fasten the guide bars to the lower frame 7/32 inch from and outside of the bottom bars, for the shafts must move between them.



Fi. 67B.—The Elevation Planes Complete

When the frames are done smear some glue on the bars, struts and frames and put a piece of silk over them just as you did with the main planes. Let them dry and then turn them over, glue the edges to the under side of the reeds and trim off the edges. Cut out the silk between the bottom bars and guide bars of the lower planes for the shafts to pass through.

Make two H frames by cutting off four *uprights*, or stanchions, each 3 inches long and trimming down the ends to fit the holes in the top and bottom bars; glue and nail a bar made of the ⅛ by 3/16 inch stick and 2 inches long to the middle of each pair of uprights; to the middle of the middle bar *screw* on a stick, called a shaft, ⅛ by 3/16 by 2¾ inches long and shave off the ends marked *gg* in Fig. 67B. Glue and set the ends of the uprights into the holes in the top and bottom bars and be sure to get the planes the same distance apart all round.

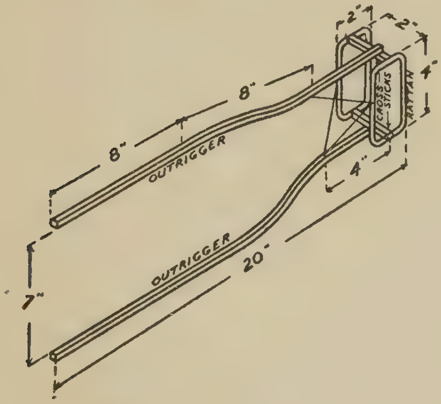


Fig. 68.— The Rudders

All that remains to be done as far as the elevator planes are concerned is to smear some glue on the ends of the shafts *gg* and force them into the holes *gg* of the front strut of the chassis (see Figs. 63 and 67).

**The Rudder Next.**— For this element you will need (1) two pieces of rattan 3/32 inch in diameter and 25 inches long; (2) two sticks of wood ⅛ inch square and 20 inches long, for the outriggers and (3) two cross-bars 3/32 of an inch thick and 2 inches long.

Steam and bend the rattan reeds to the size and shape shown in Fig. 68 and steam and bend the outrigger sticks to the shape also shown in this figure. Cover the rattan frames with silk and give them a coat of collodion. Glue and nail the frames to the cross-bars and then screw one end of an outrigger to the middle of one of the cross-bars and do the other one the same way. This permits the rudders to be swung right or left and when you have them set right, guy them out with thin wire to the outrigger.

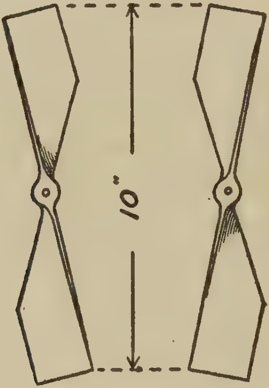


Fig. 69.— The Wright Propellers

Set, now, one of the free ends of the outrigger *under* the *upper* plane, and the end of the other outrigger *under* the lower plane and have them come directly under the middle of each plane and nail and wire them fast as shown in the skeleton of the airplane. (Fig. 70.)

**And the Propellers Last.**— The final operation is to put on the propellers which should be *scale reductions* of those used on the full-fledged Wright machines as shown in Fig. 69.

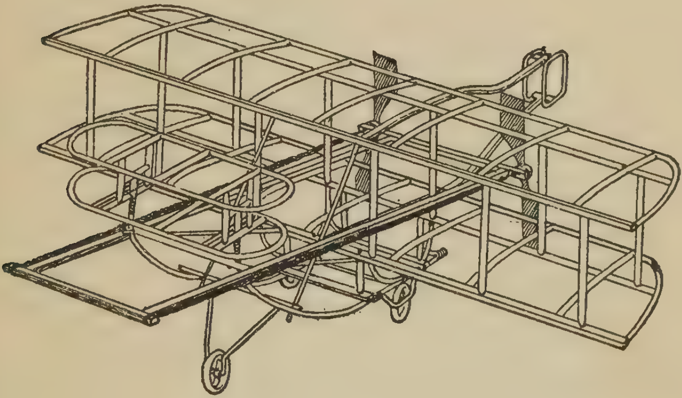


FIG. 70.— THE SKELETON FRAME

Buy a pair of 10-inch propellers, or make them yourself as per Chapter V, and be sure that they are *right* and *left* handed, for they turn in opposite directions. Slip them over the ends of the propeller shafts with their hollow surfaces turned *out* from the body of the model; put a washer over each shaft and screw on a nut. To keep the propellers from slipping on their shafts, screw the flanges of the shafts to the hubs of the propellers. The whole model when finished and ready to fly should not weigh more than 14 ounces.

The skeleton frame of the model after all the parts are assembled is shown in Fig. 70 while the little machine complete and in the air is shown in the picture following this chapter.

**Flying the Little Wright.**—See that the elevation planes are tilted up a little in front and that the rudders are exactly at *right angles* to the main planes.

Build a slanting *runway* using a board 6 or 8 feet long and have one end raised from the ground about 5 feet and the other end about 6 feet. The model will rise from the ground but it makes a prettier flight by using the runway.

Wind up the rubber motor by turning the right hand propeller, as you hold the back of the machine toward you, in the direction the hands of a clock move and when you have made 250 turns or so, hold it and turn the left hand propeller in the *opposite* direction making an equal number of turns and your airplane is energized for business.

Set the model on the high end of the board and let go of both propellers at the same time. It will run down the slope for four or five feet and gently soar away into the air as though it were endowed with a bird's brain.

THE WRIGHT MODEL IN FLIGHT

## CHAPTER VII

## MAKING A CURTISS FLYING BOAT

The last fundamental development in the airplane line was the flying boat.

This is a machine that combines an airplane with a sea-worthy boat and it is so made that it will rise from, fly over and land on the water and, what's more, it will skim on the water at high speeds.

To make a scale model of a Curtiss flying boat is just as easy as it is to build either the Blériot or Wright machines but to build one so that it will rise from the water under its own power and still hold to the *specifications* of the big flying boat is quite another matter.

Now what I propose to do is to tell you how to build a scale model of the Curtiss flying boat but you'll have to launch it in the air and then at the end of this chapter I'll tell you how to fix it up so that it will rise from the water without any help on your part but it will no longer be a scale model. Either way, though, is wonderful enough to repay you for building it.

**The Parts of the Flying Boat.**— The flying boat combines some of the features of the Blériot monoplane and the Wright biplane besides having some other novel features which neither of the latter airplanes can boast of as you will see in short order.

The chief parts that go to make up the flying boat are:

(1) The *boat* itself.
(2) The *rear planes* which include the *fin,* the *tail,* the *rudder,* and the *elevators.*
(3) The *biplane cell* and to this is fixed the *motor bed,* the *ailerons* and the *pontoons,* and
(4) The *motive power* and this is made up of a pair of *rubber skeins,* the *conversion gear, propeller shaft* and the *propeller.*

**Things Needed for the Boat.**— As in building the models that have gone before you will need all the tools described on page 73, together with the glue, brads, fine wire, etc. Wherever wood is needed use basswood if you can get it.

You will need (1) four sticks 5/32 inch square and 24 inches long for the side bars, or *longerons* as they are called, which allows ½ an inch for bending; (2) one stick ¼ inch square and 2¼ inches long for the bow *strut;* (3) one stick 3 inches long, ⅜ inch thick and 7/16 inch wide for the *stern-post;* (4) one stick 5/32 inch square and 17 inches long for the *stanchions;* (5) one stick 5/32 inch square and 17 inches long for the *top* and *bottom struts;* (6) a piece of wood ⅛ inch thick, ½ inch wide and 2¼ inches long for the *bed* on which the planes rest; (7) two sticks 3/32 inch thick, 5/32 inch wide and 5 inches long for the *hood-bars;* (8) a couple of yards of bamboo paper to cover the whole model; (9) a couple of ounces of shellac varnish; (10) a sheet of *aluminum* 6 by 9 inches *on the sides* and No. 34 gauge for the *spray hood;* (11) a thin sheet of tin 2¼ by 2 9/16 inches on the sides for the *front* of the hood; and (12) two strips of cork 1/16 inch thick, 5/32 inch wide and 12 inches long.

Begin the boat by bending the sticks for the beams in a form made of nails as described in Chapter V on page 76, exactly to the shape shown at B in the side view Fig. 71. While these are drying take the ¼ inch square stick for the *front strut* and cut it down to a three sided bar as shown in the detailed drawing, A, and make it 2¼ inches long.

Make the *bed* on which the planes rest next by trimming off the corners of the ½ inch wide block of wood and notch it in the middle as shown in Fig. 74. The bed also serves as the second strut. Form the *stern-post* now by whittling down the ⅜ by 7/16 inch stick or by getting a stick of a dealer and cutting it to the shape as shown in Fig. 72 and notch it 1¼ inches from its upper end. As the drawing shows it is 3 inches long.

From one of the 5/32 inch sticks make four stanchions 2¼ inch long and two stanchions 1½ inches long as shown in Figs. 71 and 74. From the other 5/32 inch stick cut off *five* struts 2¼ inches long and two struts

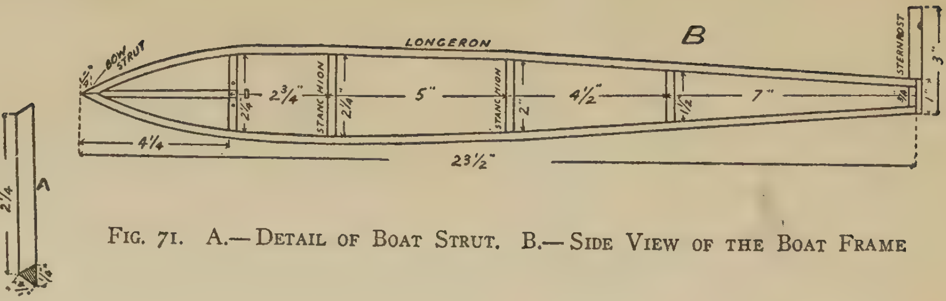


FIG. 71. A.—DETAIL OF BOAT STRUT. B.—SIDE VIEW OF THE BOAT FRAME

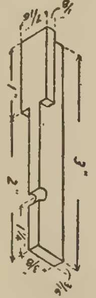


FIG. 72.—THE STERN-POST

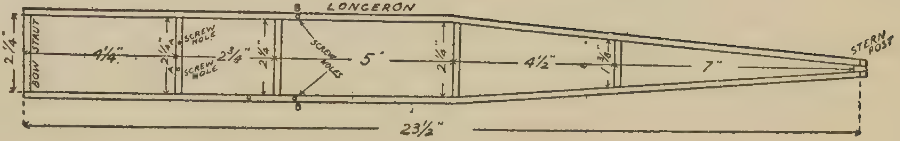


FIG. 73.—TOP AND BOTTOM VIEW OF THE BOAT FRAME

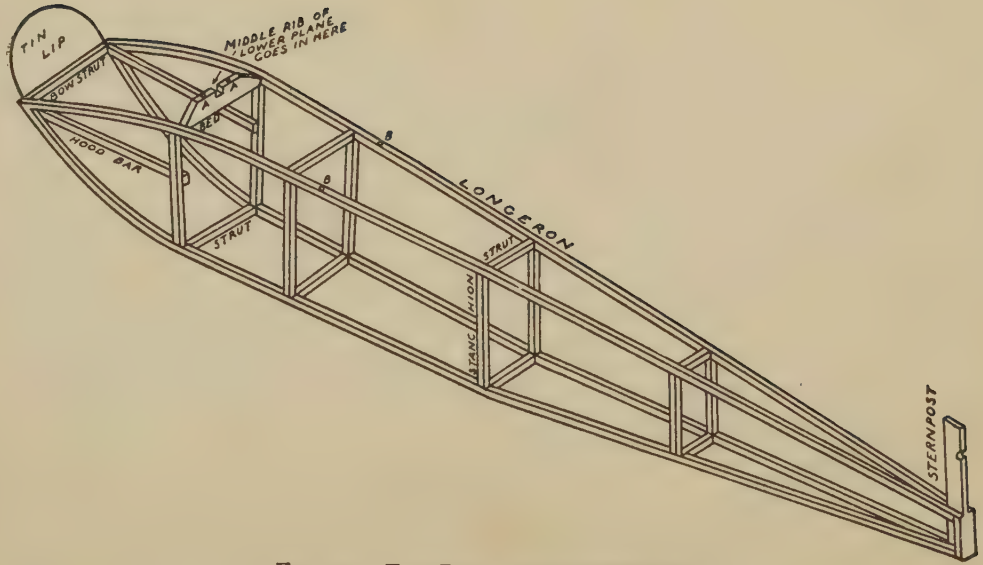


FIG. 74.— THE BOAT FRAME WHEN DONE

1⅜ inches long for the top and bottom of the panel as shown in Figs. 71 and 74.

When the longerons are dry lay the curved ends together and mark and cut them so that they will make a sharp point. Glue and nail — with brads — these ends to the three sided strut and fasten the straight ends of the sticks to the stern-post as shown in Figs. 71 and 74.

Glue and nail the bed strut and the other five 2¼ inch struts to the top and the bottom of the plane and have them at the distances apart shown in Fig 73 while Fig. 74 shows how they are set. Now place the stanchions between the side longerons and have them the same distance apart as the struts. To the front ends of the longerons on the sides of the frame glue the 3/32 by 5/32 inch hood bars and fasten the other ends of the bars to the first pair of stanchions as shown in Fig. 71.

Cover the frame with bamboo paper and varnish the boat a couple of times. When it is dry take two strips of cork 1/16 inch thick, 5/32 inch wide and 12 inches long and screw them with ¼ inch flat-headed wood screws to the curved ends of the bottom longerons for water runners.

And now for the spray-hood. Cut a piece from the sheet of tin or aluminum to the size and form shown at A, Fig. 75, for the tongue of the boat and drill five 3/32 inch holes around the edge. Screw the straight edge of this tongue to the under side of the bow strut so that it will project out and up from it, From the sheet of aluminum cut a piece to the size and form shown at B; drill holes along its edges and bend it to the shape shown at C. Screw the hood to the hood bars of the frame with ¼ inch round headed brass screws through the first three holes on each side and then wire the hood to the tongue through the three upper holes and the boat of your sea-plane is done.

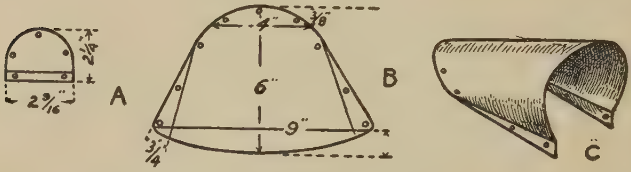


Fig. 75.— The Spray Hood
A. The Pattern
B. The Tongue
C. The Finished Metal Hood

**The Rear Planes.— The Fin.—** This fishy member is simply a three cornered frame made of ⅛ inch square sticks, the upright being 1½ inches long, the upper bar 8 inches long and the lower bar 9 inches long as shown in Fig. 76. Cover both sides of the fin with paper and varnish it and when dry wire it to the front of the stern-post and to the last strut of the hull of the boat.

**The Tail.—** Make and put the tail on next. Cut a ⅛ inch round stick 7 inches long and two ⅛ inch square sticks 7½ inches long and glue and wire them together, forming a triangle as shown in Fig. 77. Cut two more square sticks 6 inches long for the braces and trim off the ends so that they will fit in the sharp end of the frame and glue them in place.

Cover the tail with bamboo paper and varnish. When dry cut a strip out of the paper between the braces and 4 inches long from the stern post toward the *apex* to allow the fin to project through the tail.

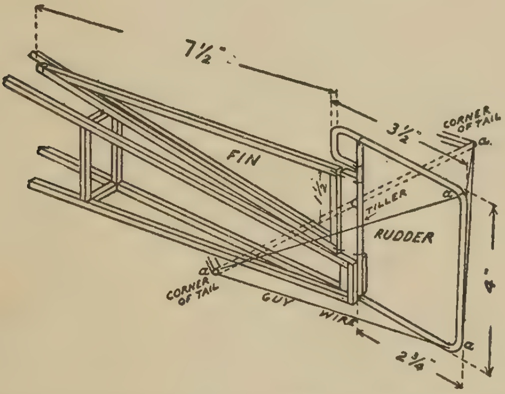


Fig. 76.—The Fin and Rudder on the Stern-Post

Make a brace of a piece of aluminum wire ⅟16 inch in diameter and 3¾ inches long; flatten the ends, drill a hole through each one and bend the wire as shown in Fig. 77. Straddle the brace over the fin and screw the ends to the longerons of the boat 5½ inches from the stern-post.

Set the tail in place with the round stick in the notch of the stern-post and let it down with the slot over the fin and the front end resting on the brace and wire it fast to the latter.

**The Rudder.**— After the tail is on you can make and set the rudder. Take a piece of rattan ⅛ inch in diameter and 12¼ inches long and steam and bend it to the shape shown in Fig. 76. When this is done wire a round stick ⅛ inch in diameter and 3¾ inches long to the ends and the top of the rattan edge and cover it with bamboo paper and varnish.

Fasten the round stick or tiller bar to the stern-post with wire and guy out the rudder with wires from the corners *a a,* in Fig. 76 to the corners of the tail *a a* in Fig. 76.

**The Elevating Planes.**— There are two of these elevators and they set back of the tail, and in a line with it on either side of the rubber, and at right angles to it.

Get (1) two rattan reeds 3/32 inch in diameter and 8½ inches long and steam and bend them to the form shown in Fig. 77 for the edges; (2) two 3/32 inch round sticks 3¼ inches long for the spars; (3) two 1/16 inch round sticks 2 inches long for the cross-trees, and (4) two sticks 1/16 inch thick, 3/16 inch wide and 4 inches long for the braces.

Wire each cross-tree to the middle of a spar and then wire the ends of a spar to the ends of one of the rattan edges and finally wire in a brace. When are frames are done cover with bamboo paper and varnish them.

Fasten the spars of the elevators to the round cross-stick of the tail with wire in the positions shown in Fig. 77 and guy them out with wires running over the ends of the cross-trees and fasten them to the top and bottom bars of the tail. The illustration at the end of this chapter shows the flying boat and a glance at it will show you exactly how the fin and the rudder set at right angles to the tail and the elevators. It looks pretty complicated but when you build it up piece by piece it's all simple enough.

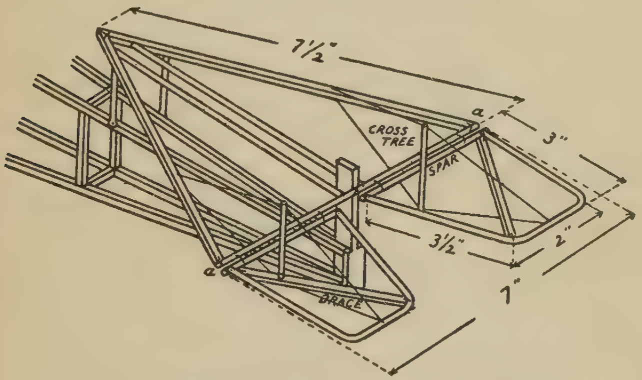


Fig. 77.—The Tail with the Elevation Planes Mounted on It

**The Main Planes.**— There are two planes, one mounted above the other and so forming a biplane cell.

The planes are built up a little differently from those described in the foregoing chapters, in that instead of the ribs being made of one piece of wood, each rib consists of two thin pieces bent to form.

The materials needed for both planes are (1) two reeds of rattan ⅛ inch in diameter and 15½ inches long for the *rear edges;* (2) one stick of wood ⅛ inch thick, ¼ inch wide and 35¾ inches long for the *front spar* of the top plane; (3) one stick ⅛ inch thick, ¼ inch wide and 28¾ inches long for the *rear spar* of the top plane; (4) one stick ⅛ inch square and 2 inches long for the *braces;* (5) two strips 1/16 inch thick, ⅛ inch wide and 21 inches long for the ribs, and (6) one stick ¼ inch square and 35½ inches long for the *motor bed.*

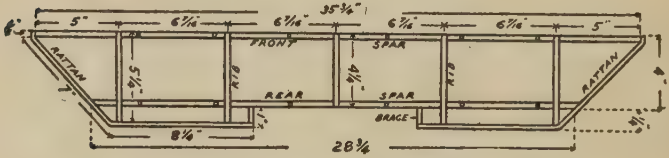


FIG. 78.—THE FRAME OF THE UPPER PLANE SHOWING THE AILERONS

For the lower frame get (7) two sticks ⅛ inch thick, ¼ inch wide and 26 inches long for the front and rear spars; (8) two rattan reeds ⅛ inch in diameter and 8 inches long; (9) one stick 1/16 inch thick and ⅛ inch wide and 25 inches long for the ribs; and (10) one stick ⅛ inch square and 2 inches long for the braces. And for the stanchions cut off (11) twelve pieces of round wood 3/32 inch in diameter and 5¾ inches long.

Begin by steaming and bending each piece of the rattan to the shape shown in Fig. 78. When these are dry wire the bent ends to the ends of the long spar and wire the next longest spar to the rattan 4 inches from the first one. Set the 1 inch braces between the ends of the rattan and the rear spar and wire them in place as shown in Fig. 78.

With the outline of the upper plane done measure off five points on the front spar, according to the figures along the edge of it, for the ribs. To make the ribs cut off the 1/16 inch strips into lengths 5⅜ inches long and steam and bend them in a form made of nails exactly like the curve shown at A in Fig. 79.

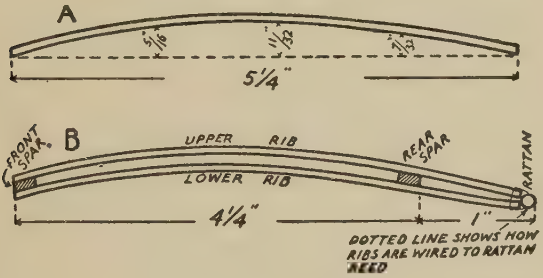


Fig. 79.—The Ribs
A. Showing the Curve
B. The Ribs on the Frame

When these ribs are dry glue one on top and one on the bottom of the spars of the plane right under it as shown at B at each of the points marked and when dry wire the front ends to the spar and the rear ends to the rattan and draw the ends of the lower ribs up close to the upper ribs so that both of them will be flush with the rattan. The bottom plane is a little different from the top one in that the front and rear spars are of the same length and the frame is shorter.

Cut from the ⅛ by ¼ inch sticks two spars 26 inches long and measure off five points on both spars even with the ribs of the top plane. Then make five pairs of ribs of the 1/16 inch strips 5¼ inches long as before and glue and wire these to the front and rear spars at each of the points marked and draw up the ends of the lower ribs flush with the rattan.

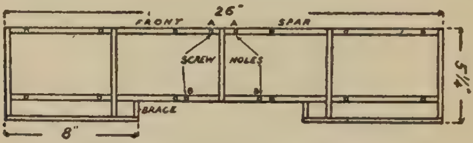


FIG. 80.—THE FRAME OF THE LOWER PLANE WITH THE AILERONS

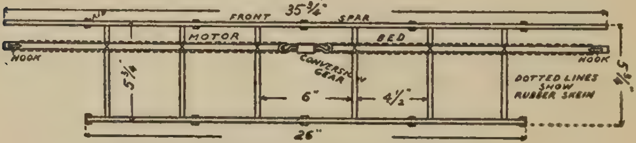


FIG. 81.—FRONT VIEW OF PLANE CELL

When dry wire an 8 inch length of rattan to the ends of the ribs and brace these with a ⅛ inch stick of wood 2 inches long.

Next mark off six points on the front and rear spars of the upper and lower planes at the points marked with circles shown in Figs. 78 and 80 and drill $^3/_{32}$ inch holes at these points for the uprights, or stanchions, and when this is done cover the upper and lower planes with bamboo paper on both sides and put on a couple of coats of shellac varnish.

When the planes are dry smear a little glue on the ends of the stanchions, each of which are $^3/_{32}$ inch in diameter and 5½ inches long, and set them in the holes in the upper and lower planes as shown in Fig. 81 and see that the latter are even all round. Fig. 82 shows the skeleton framework of the main-plane cell looking at it from the back.

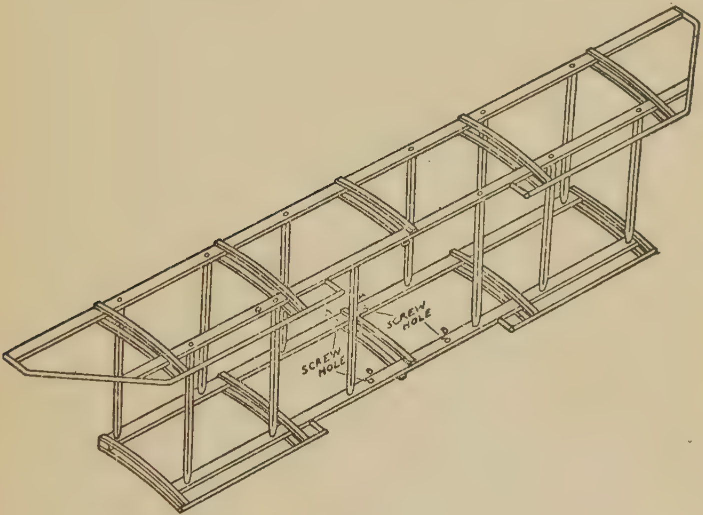


FIG. 82.—THE FRAME OF THE BIPLANE

**The Conversion Gear.**— Your next move is to get a *conversion gear* as shown in Fig. 83. Unless you have a lathe and are handy with tools you had better buy the gear ready made as it must run perfectly true and with as little friction as possible.

A conversion gear made especially for this motor boat can be bought with propeller shaft and bearings complete for $1.50 or you can tackle making one from the drawing shown in Fig. 83.

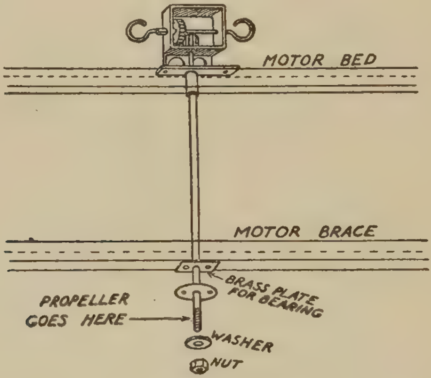


FIG. 83.—THE GEAR MOUNTED IN THE UPPER PLANE

**The Motor Bed.**— To attach the gear to the *motor-bed* drill a 3/32 inch hole through the ¼ inch stick exactly in the middle, and ½ inch from each end of the stick drill a hole and set in a wire hook as shown in Fig. 83. Fasten the stick, or bed, to each one of the front row of stanchions with wire 1 inch below the front spar of the upper plane, as shown in Fig. 83.

Now make a block ¼ inch square and 1 inch long, drill a ⅛ inch hole through the middle and screw this block to the middle of the rear-spar of the top plane. Push one of the bearings through the hole in the motor bed and the other bearing through the hole in the block on the rear spar. The holes must be exactly in a line with each other or the shaft will stick.

**The Rubber Motor.**— For the motor use two 25 foot lengths of ⅛ inch square rubber strand. Tie the ends of each strand together and double it back on itself until you have a skein of 10 loops. Slip each of the looped ends of the skeins on a hook of the conversion gear and then to one of the end hooks.

**The Ailerons.**— In the big Curtiss flying boats the *ailerons,* or balancing planes, sometimes set between the upper and lower planes and sometimes they are placed even with the upper plane but in either case they are fastened at the rear ends of the planes.

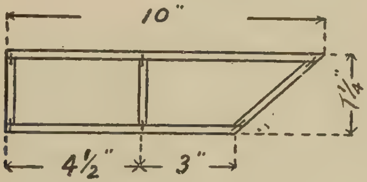


Fig. 84.— The Aileron

These ailerons are simply flat surfaces, the frame of each one for the model being made of ⅛ by 3/16 inch sticks cut to the lengths shown in Fig. 84 and glued and wired together at the corners with a brace in the middle. The frames are covered with bamboo paper and varnished, then secured with wire to the middle of the rear end stanchions and guyed out with wire to the upper and lower rear spars of the planes as shown in the illustration at the end of this chapter.

**The Pontoons.**— The pontoons, or floats are made of a slab of cork ⅛ inch thick, 1 inch wide and 4½ inches long cut to the shape shown in Fig. 85.

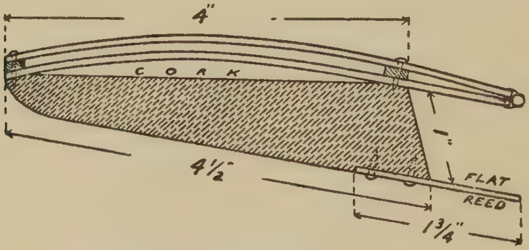


Fig. 85.— The Pontoons or Floats

To the wide end of each cork screw on a flat piece of rattan 1/16 inch thick, 3/16 inch wide and 1¾ inch long. Each float is fastened to the under side of the outside rib of the lower plane by screwing the front and rear spars to it.

**Mounting the Planes on the Boat.**— If now you will go back to Fig. 80 which shows the main planes you will see two holes in the front and two holes in the rear spar of the lower plane and these are marked AA and BB.

Look now at Figs. 73 and 74 which show the hull of the boat and you will also see four points marked

AA and BB. Set the planes on the boat so that all of the A holes come together and all of the B holes come together and this will bring the bottom of the middle rib of the lower plane into the groove of the strut. Screw the front spar fast to the strut and the rear spar fast to the longerons, when the planes will be rigidly fast to the boat.

**The Propeller.**— There is only one little thing left to do and this is to put a 10 inch propeller of the type shown in Fig. 86 on the shaft with the hollow sides of the blades toward the back, slip on a washer, screw on the nut and then screw the flange of the shaft to the hub.

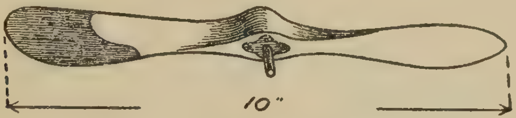


FIG. 86.— THE CURTISS PROPELLER

A propeller of the kind and size needed, carved and fit for business, may be bought for about 85 cents or if you want to try your hand at making one read the next chapter. The completed Curtiss flying boat is shown at the end of this chapter.

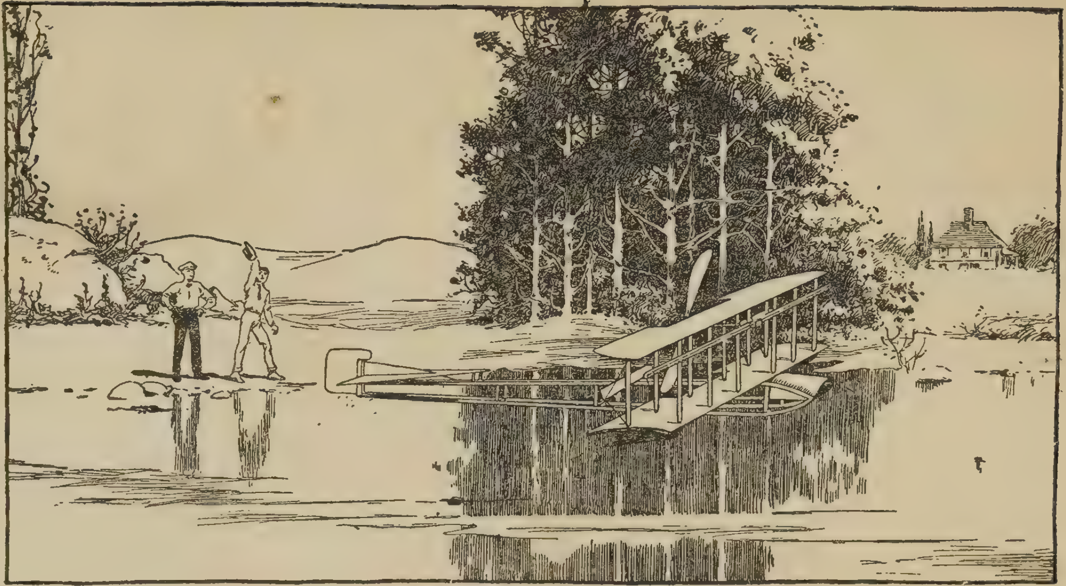
**Launching the Flying Boat.**— To fly the model take it to the edge of a lake or other body of still water. Energize the motor by twisting up the rubber bands 150 to 200 times by turning the propeller clockwise.

Now hold the flying boat well up in the air with the planes even, the bow of the boat tilted up slightly and with the rudder close to your shoulder. Let go of the propeller first and then push the machine firmly but softly from you and let it go.

If rightly made it will fly 25 or 30 yards and gracefully alight on the water when it will skim over the surface at a good clip for another dozen yards or so.

**Some Tips on Flying.**— You must have the main planes, ailerons, elevating planes and rudder set right if a good flight is to be had. The planes must be even and perfectly balanced. The ailerons should be guyed out horizontally between the planes; the elevating planes should be guyed out even with the tail to make the machine rise, and finally the rudder should be set in a line with the long *axis* of the boat if a straightaway flight is wanted.

**To Make the Model Rise From the Water.**— To make the model rise by its own power from the surface of the water take off the propeller, the conversion gear and the motor bed and put on instead a motor frame like the one used for the Wright biplane. Fasten it between the planes and use two 8-inch propellers to drive it.



The Curtiss Flying Boat

## CHAPTER VIII

# MAKING YOUR OWN AIRPLANE

In the chapters that have gone before I have told you how to build several types of airplanes from known measurements but there are certain rules and kinds of materials you ought to know about if you intend to build models from your own plans.

Model airplanes are of two general kinds and these are (1) models that are made to fly as far as possible, and (2) models that are scale reductions of big machines, or as nearly so as conditions will allow and these also fly but they are too heavy for the motors they are powered with to fly far.

**The Chief Factors of Success.**— The chief secret of making a good flying model airplane is in keeping down its weight and giving it all the power it will carry.

You must make your models light because with rubber skein motors, which are the only practical kind to use on 3-foot machines, you can't get up enough speed to carry heavy loads.

If you intend to become an expert in making and flying airplanes and will do some experimenting with the models I have described, you can no doubt make many of the sticks smaller than the sizes called for, or use wire instead, and they will still be strong enough to sustain the other parts including the motor.

**The Best Shape for the Fuselage.**— In drawing the plans for a model which is to include your own ideas of construction you can't do better than to follow the rules laid down by Johnson which are:

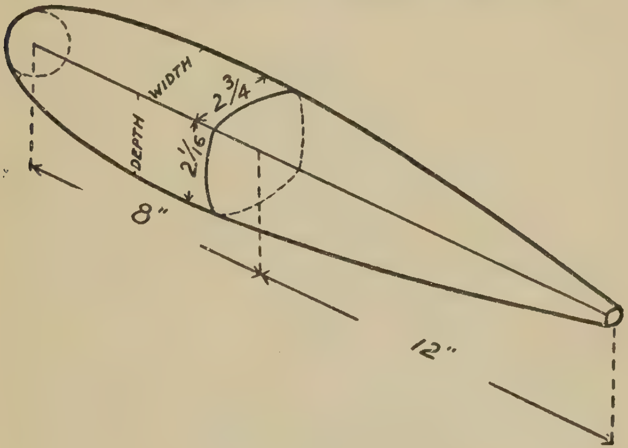


Fig. 87.— The Stream-line Body

(1) That the largest part of the fuselage should be two-fifths of its whole length measured from its forward end; (2) that its width and thickness should be as four is to three, that is, if its width is four inches, its thickness should be 3 inches, (3) that its length should not be less than 5 times nor more than 9 times its width. (4) That the forward end should be rounded and its stern as small as it can be made;

and (5) that the whole framework which is exposed to the air should be covered to make it smooth. Fig. 87 shows that these rules give a *stream-line* body which is the shape that offers the least resistance to the air.

**The Design of the Main Planes.**— A model airplane must have a good natural balance, or *stability,* as it is called, to keep it straight in the air when in flight.

It may seem curious that a flat plane will keep its balance when driven through the air and that a curved plane must have a tail to balance it.

A monoplane is not as *stable* in flight as a biplane and besides the latter has more lifting surface with a smaller spread of *wing.* This makes it easier to start a biplane, for the air has more surface to press against but it also makes the model heavier on account of the stanchions connecting the planes.

The *transverse,* that is the *sidewise balance* of an airplane is helped along by the use of a fine, or *vertical keel* and also by setting the planes at a slight V angle, called a *dihedral angle* or *positive angle,* but this form requires a larger surface and so adds to the weight. To get the same effect the ends of the planes can be turned up a little, leaving the lifting part of the plane either flat or curved as before.

To get *longitudinal,* that is *lengthwise balance,* the main planes and the rear planes should be at least four times the distance apart of the width of the main plane, that is to say, if the main plane is 4 meters wide the rear planes should be placed 16 inches from it.

The *aspect ratio* of the main plane, which means the *span,* that is the spread or distance from tip to tip, in relation to its *depth,* can be found by dividing the *span* by the *chord,* see Fig. 88. The deeper the curve of the plane the greater is supposed to be its balance and its *lift* is also increased, likewise its head resistance.

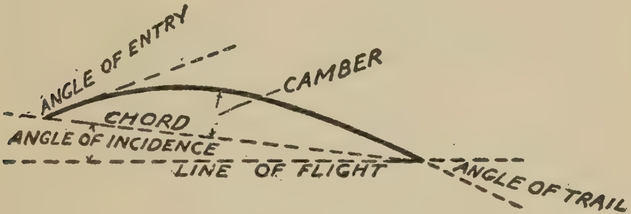


FIG. 88.— THE CAMBER OF THE MAIN PLANE

The *angle* at which the curved plane sets, called the *angle of incidence,* should be small to get the best results. In the Wright biplane the angle is only 2 or 3 degrees while in the Blériot *airbus,* built some years ago, the angle was at least 12 degrees. So try it out for yourself.

There is one thing more to be done in building your models as far as their design is concerned and this is to have the *propeller thrust* pass through the *center of pressure,* and the *center of gravity,* all of which is explained in Chapter XI.

**The Choice of Materials.**— *Wood.*— There are many kinds of wood that can be used for making model airplanes and among them is basswood, silver spruce, ash, maple, poplar, whitewood, white holly pine and mahogany.

Bass is a good wood for making all parts of an airplane where wood used for it is free from knots, soft, light and easily bent. When you order it say that it must be straight grained and well seasoned. It can be bought of dealers in model supplies in all sizes from ⅛ inch up to ½ inch square, in round sticks called *dowling* and in I and T shapes as shown in Fig. 89A. These latter shapes are very strong considering their light weight.

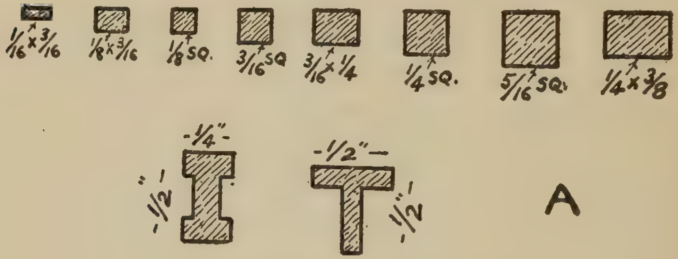


Fig. 89A.— Sizes and Shapes of Wood

*Silver spruce* is also largely used and while it is not as light as bass it is much stronger. *Ash* is another fairly light and strong wood and is useful when made into I and T sections. *Maple* is a close grained wood and can be used for making the spans and braces of planes.

*Poplar* and *whitewood* are very light and easy to work with especially if you are making propellers. *Birch* is a good wood that can be used for the ribs of wings, but *white holly* is the best wood for ribs because you can bend it so easily to shape when it is steamed or soaked in hot water.

Our good old friend *pine* is used in making big machines and it can be employed to advantage in your models for it is light and easy to work but it also breaks very easily. Probably for this reason dealers do not list it except for making propellers, while *Honduras mahogany* — the light weight kind that cigar boxes are made of — is also used for propellers.

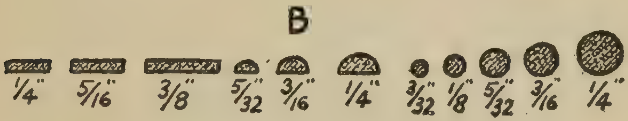


FIG. 89B.— SIZES AND SHAPES OF RATTAN

*Rattan.*— Rattan reed which is cut from the stems of the palm tree is light and springy and is a great shock absorber.

It is made very limber by steaming or soaking in hot water and can be easily bent to any shape. For this reason it is largely used for wing edges, chassis frames and skids. It can be bought in flat strips, half-round and round reeds and comes in 6 foot lengths. See Fig. 89B.

*Bamboo.*— This is very elastic and while I have said nothing about its use in the foregoing chapters it is light and tough and is especially good for making ribs, shock absorbers, skids, etc.

It can be split into thin strips and bent by steaming or heating it in the flame of an alcohol lamp. Indeed, its tendency to split easily is the worst thing about it so in fastening it to other pieces always drill a hole in it first or use wire to make the joint.

**Kinds of Covering.**— *Silk* makes the lightest and strongest covering for planes. *Silk gauze,* or *silk bolting cloth* is the lightest silk that can be used for the purpose but Japanese silk is light enough for all ordinary models and it is quite strong besides. In putting the silk on the frames of planes, tails, etc., stretch and glue it on endlong first and then crosswise.

*The Coating Solution.*— Whichever kind of silk you use coat it over several times with *collodion,* a liquid made by dissolving gun-cotton in *ether* and which you can buy of dealers or at drug-stores. Use a flat camel's hair brush to put it on with and lay it on thin and smooth. When dry, the silk will be air tight, waterproof and much stronger than before it was applied.

*Bamboo Paper.*— Next to silk, bamboo paper is chiefly used for covering planes. It is a *fabric* made of the fibers of bamboo in the mills of Japan. It is light and is made in *clear* sheets and also with the fibers showing.

*Coating Varnish.*— After the bamboo paper is stretched on the planes, or frames, it should be coated with *shellac varnish,* made by dissolving gum shellac in alcohol, or you can buy it ready made.

*Gold Beater's Skin.*— This is a skin used by gold beaters for making gold leaf. It is lighter than tissue paper, tougher than bamboo paper and is as smooth as glass.

These skins come in sheets about 3 inches wide and 32 inches long but you can make as large a surface as you need by gluing a number of them together. In gluing the skins on the frames don't stretch them but when the glue is hard hold them over a steaming kettle and let them dry again. Coat them on both sides with shellac varnish and you will have a fine, smooth, light plane.

*Paper Fiber Sheets.*— Fiber comes in sheets of all thicknesses and is sometimes used for the planes of fliers as it is stiff enough to keep a curve without the use of ribs if the edges are held fast.

*Rice Paper.*— For the lighter racing fliers Japanese tissue paper makes a good covering for it is light and tough when coated with shellac varnish.

*Aluminum.*— Thin sheet aluminum makes a light, smooth covering that can be given any curve. It can be had in any thickness from 1/150 of an inch which is No. 34, to 1/25 of an inch which is No. 18. You can buy it in sheets as large as 12 inches wide and 6 feet long or any smaller size you need.

*Wood.*— Thin poplar boards 1/16 inch thick, can be used for the planes of sling-shot fliers but they cannot be called a success for the larger models.

**The Metals.**— *Steel* is used in many ways in model airplane construction. Propeller shafts, balls for ball bearings, hooks for rubber skeins, eyebolts, screw-eyes and wire are all made of steel.

*Steel piano wire* can be used instead of rattan, bamboo or wood for the spars of planes, frames of chassis, etc., as it is light, elastic and can be bent without previous preparation. An English model airplane builder says that steel umbrella ribs make good spars for the planes, piano wire for the trailing edges and steel wire for the stays.

*Aluminum.*— This is the lightest useful metal and is much used for *sleeves,* shaft-hangers, propellers and even for covering planes. It can be used in rods, tubes and sheets. The worst thing about aluminum is that it is so confounded hard to solder.

*Magnalium.*— This is an *alloy* of aluminum and magnesium. It's a trifle heavier than aluminum but it is stronger and can be soldered.

*Brass.*— Of course this alloy is used for all purposes — screws, bearings, forks, gears, chains and fittings.

**Joints, Fittings, and Wheels.**— *Joints.*— Fig. 90 shows a number of joints and sockets for joining sticks together. The good ones are *hard soldered* and add but little to the weight of the model and much to its strength.

*Fittings.*— Turnbuckles, bolts, eye bolts and eyelets that are exact reductions of the real ones are made for scale models (see Fig. 91A), while springs for shock absorbers, forks for holding wheels, axles and shafts and bearings as shown in Fig. 91B all come in miniature sizes.

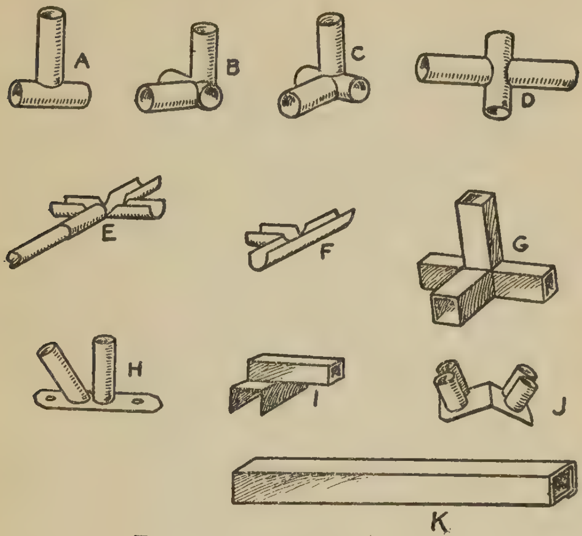


FIG. 90.—SOME METAL JOINTS

*Wheels.*—Little wheels the size of a silver dollar made of tin, *laminated* wood and burnished aluminum,

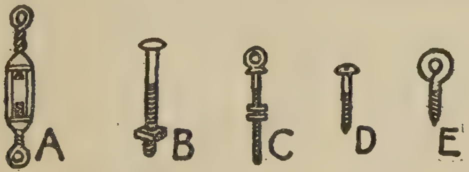


FIG. 91A.—A FEW SMALL FITTINGS

solid or spoked, with stream lines and pneumatic tires are made at prices so low you wonder how they do it. The wheels are strictly for scale models, but while they add weight they multiply beauty. Fig. 92 shows the several kinds.

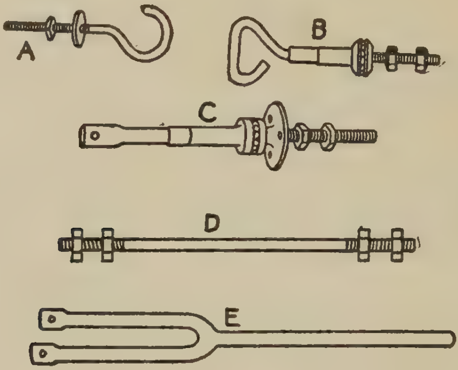


Fig. 91B.— Some Larger Fittings

**Now For the Motive Power.**— *The Rubber Motor.* — There is only one kind of a motor that can be used with success on model airplanes and this is made of rubber strands.

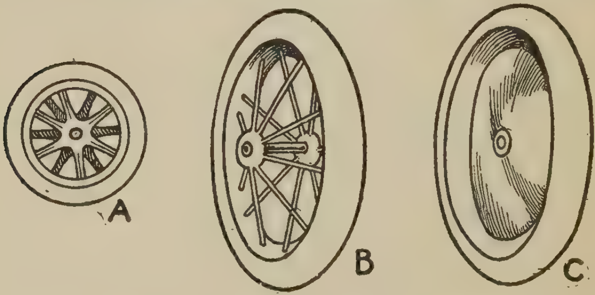


Fig. 92.— Kinds of Airplane Wheels

Yes, it is far and away the most simple and powerful of all motors for its weight and while rubber is most common there are some very uncommon things about a rubber strand motor.

**The Kind of Rubber to Use.**— The kind to use for motors is fresh, pure *Para* rubber; it comes in *flat* and *square* strands but there seems to be a good deal of difference in opinion among men who know as to which is the best, but let's say with the Wading River fellows that flat rubber is the thing for fliers and that square rubber should be used for scale models.

**The Size You Need.**— Flat rubber strands are cut ⅛ and 3/32 inch wide and can be had in any length up to 200 feet, while square strands are made in 1/16, 3/32 and ⅛ inch cross section and in lengths of 78 to 190 feet.

**Testing It.**— A flat fair *test* for rubber strand is to take a yard of it and stretch it repeatedly 7 times its natural length and see that it shows no flaw; then stretch it 10 times its natural length and if it does not break call it a good piece.

*Its Power.*— When a strand of the right size and length is doubled back on itself forming a skein, the skein hooked to a propeller and *wound up* the proper number of times it will drive a flier nearly half a mile and keep it in the air for a minute or more.

What is more, enough power can be stored up in a rubber motor to propel a model having a 6 foot spread of wing and which weighs close to a couple of pounds but I'm not saying how far the model will fly.

*Length and Number of Strands.*—The rules laid down by Johnson state that the rubber strands should have (1) as long a reach as possible and that (2) the length of the rubber strands should be twice in inches the number of strands used; that is, if there are 8 strands their length should be about 16 inches; 10 strands 20 inches, etc.

*The Number of Turns.*— The number of *turns,* that is twists, that can be given a rubber skein grows proportionately less as the number of strands is increased. The right number of turns can be easily found by experiment, but in any case wind up the skein of rubber until there is a double twist in it from one hook to the other.

*Lubricating and Preserving the Rubber.*— To make a rubber motor do its best it must be taken care of. In the first place don't keep the rubber stretched between the hooks of your model when not in use for this saps its life and takes away its power to store up energy.

Several substances have been used to prevent the strands from sticking and among these are *talcum powder, French chalk* and *soapstone;* I have found that *powdered graphite* works better than any of the above for it sticks to the rubber where the others fall off.

*Sal soda* dissolved in water, and *pure, re-distilled glycerine* are also used but of these the latter is much the best for it does not dry off and besides it makes the rubber last longer. Other advantages of using *lubricants* or rubber strands are that they can be given more turns, make the winding easier and the *torque*, that is the unwinding, smoother.

*The Use of Gears.*— The purpose of using *gears* on models is so that two or more rubber skeins can be used to drive a single propeller instead of one skein, and this of course increases the power.

In the *conversion gear* used in the model of the Curtiss flying boat the pair of cog-wheels mesh at right angles with each other so that the two rubber skeins are in *alignment* and *parallel* with the front spar of the plane. (See Fig. 83, last chapter.)

*Multiple Shaft Gears* have for their object, (1) the use of two or more short rubber skeins instead of a single long one, and (2) a *ratio gearing* so that the propeller is driven twice as fast, or faster, than the skein unwinds. A double shaft gear is shown in Fig. 93.

By using *double*, or *triple*, shaft gears, that is gears with two or three shafts and each shaft turned by its own rubber skein, and where all the cog-wheels are of the same size, a greater amount of energy can be stored up, that is, if the gears are made right and mesh accurately and so run with the least friction.

Multiple shaft gears that are made to drive a propeller faster than the rubber skein unwinds, are of little or no value for you can't get more power out of a rubber motor than you store up in it; suppose the ratio is 2 to 1, that is, if the propeller runs at a speed twice as fast as the rubber skeins unwind it will of course take twice as much power to turn the propeller and you're back at the same place you started from.

*The Use of Two Propellers.*— Two propellers driven by two rubber skeins give better results than the use of a single propeller driven by two rubber strands through a double shaft gear.

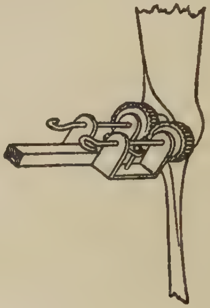


FIG. 93.— DOUBLE SHAFT GEAR

*To Test a Rubber-Strand Motor.*— At the end of this chapter a simple device is described to test propellers and by using a given propeller you can reverse the process and test your motors.

**About Other Motors.**— Spring motors are of two kinds and these are (1) the flat, coiled spring such as is used in clocks, and (2) the long spiral spring made of steel wire. The first needs a lot of gears to make it give up its power and the second can't begin to compare with the rubber-strand motor.

*Compressed air* motors have been used in flying models and a simple and light one is described in the next chapter. *Steam engines* and boilers have also been used in the larger flying models before the coming of the gasoline engine, but of all the model engines on the market that I know of not one is light enough and at the same time powerful enough to compete with the rubber motor.

*Gasoline engines* are plentiful and the weight of the smallest one is nearly 2½ pounds, though this has a speed of 2500 revolutions per minute, develops about a horse power and will drive a 16-inch propeller.

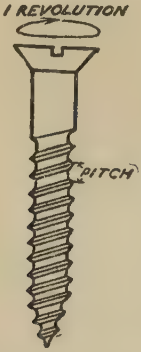


Fig. 94.—The Pitch of a Wood Screw

Finally *electric motors* are beautiful to drive the propeller of a model airplane hung in a store window for exhibition purposes but as a motive power for actual flight they are useless. The motors in themselves are as heavy as steam engines and they require storage batteries that are two or three times as heavy again to *energize* them.

**How to Make and Use Propellers.**— A wood screw has sharp threads cut on it in a spiral and when the screw is forced into a piece of wood every time it is turned once around it goes in the distance between any two adjacent threads, and this distance is called the pitch of the screw. It is shown in Fig. 94.

A propeller screws its way through the air just as a screw cuts its way into wood, that is every time the propeller makes one complete turn it should move through the air the distance of its *pitch* as shown in Fig. 95. But a propeller travels through the air only about half as far as its pitch shows that it should go and this loss is called its *slip*.

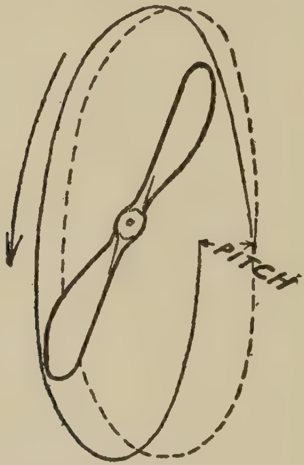


FIG. 95.—THE PITCH OF A SCREW PROPELLER

The *thrust* of a propeller is its power to move forward. A large propeller which turns slowly has a greater thrust than a small propeller that turns very fast.

The *diameter* of a propeller, that is, its length from the tips of its blades, should be about one-third the length of the main plane but where two propellers are used the diameter of each should be about one-fourth the length of the main planes.

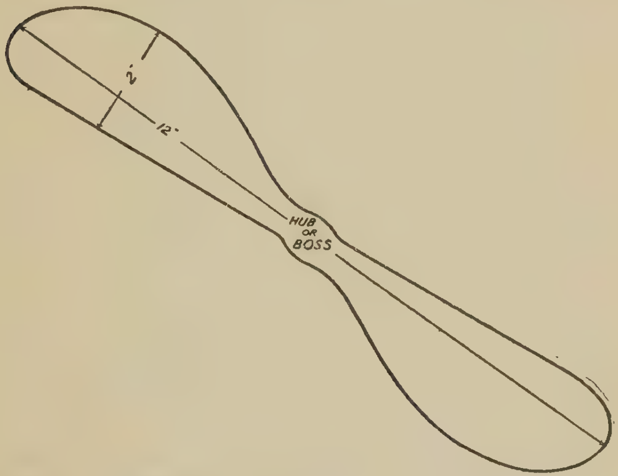


FIG. 96.— PATTERN FOR A STANDARD 12" PROPELLER BLANK

The *width* of the blades should be small, that is, about one-fifth the length of the propeller. The pattern and the sizes for a 12-inch propeller are shown in Fig. 96. There are several kinds of propellers on the market and these include the simple flat blade propeller made of sheet fiber which I described on page 63, and the standard Langley and Wright types which are shown in Fig. 97. Then there are propellers cast in aluminum and others that are carved out of wood such as poplar, pine, and white holly and even better, *laminated* ones, that is, the wood is built up of sections of spruce or maple and mahogany to keep them from warping.

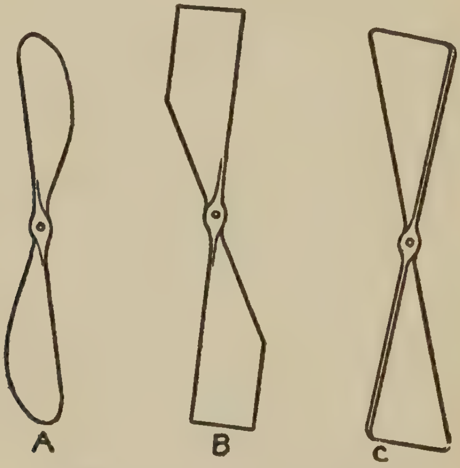


FIG. 97.—TYPES OF PROPELLERS
A. Ordinary Propeller
B. The Langley Propeller
C. The Wright Propeller

*Whittling Out a Propeller.*—Get a piece of soft wood ⅞ inch thick and 2 inches wide and saw out a *blank,* as it is called, exactly like the shape shown in Fig. 98.

Make a diagonal mark across the ends of the blanks and have the marks so that they cross each other, as shown at page 151. Then mark out the hub, or boss as our English friends call it.

Take a good sharp knife, with a large blade, and a big handle and cut away both sides of the blank as shown at B. Cut away the other sides the same way until the ends are about ¼ inch thick. Round off the upper surfaces of the blade and take a half-round chisel and hollow out the under sides until each blade is about ⅛ inch thick in the middle and ¹⁄₁₆ inch thick at its edges.

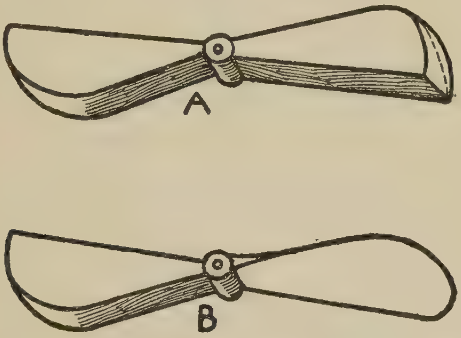


Fig. 98. A.—The Propeller Blank Marked Across Ends. B.—One Blade of Propeller Whittled.

After the propeller is cut out find its exact center by tying a thread to a pin and pushing the pin into the propeller as shown in Fig. 99. Now drill a hole the same diameter as the shaft you are to use it on and be sure to drill it straight. Test it by spinning it around on a wire and if it is not perfectly balanced sandpaper it down on one side or the other until it is so.

When you put it on the model, have the *convex* or bulging side toward the machine, that is, in the line of flight. Where two propellers are used one should be right handed and the other left handed so that they can turn in opposite directions. To make a left-handed propeller reverse the diagonal marks across the ends of the blank and whittle the blades accordingly.

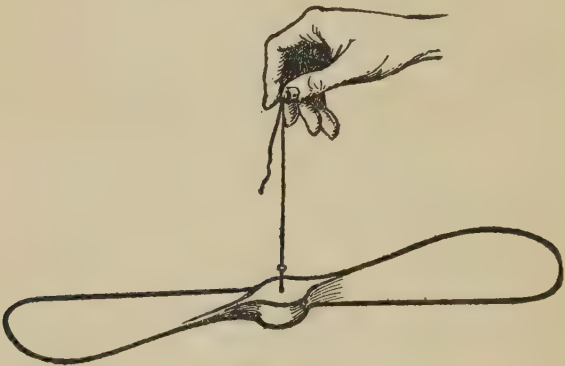


Fig. 99.—Finding the Center of the Finished Propeller

Now all this may seem vague when you read it over but if you will whittle out just one propeller you'll have the key to the whole art for it is really a very easy thing to do.

**Testing Out Propellers.**— To test the efficiency of different propellers, Johnson got up the following simple but none the less clever scheme. He strung two straight wires 150 feet long and say 10 feet apart between supports. On each of these wires he hung a frame about a foot wide and a yard long by means of small pulleys as shown in Fig. 100.

To the lower part of the frame, a rubber motor was fastened in the usual position as well as the propeller to be tested. Winding up the motor skeins to

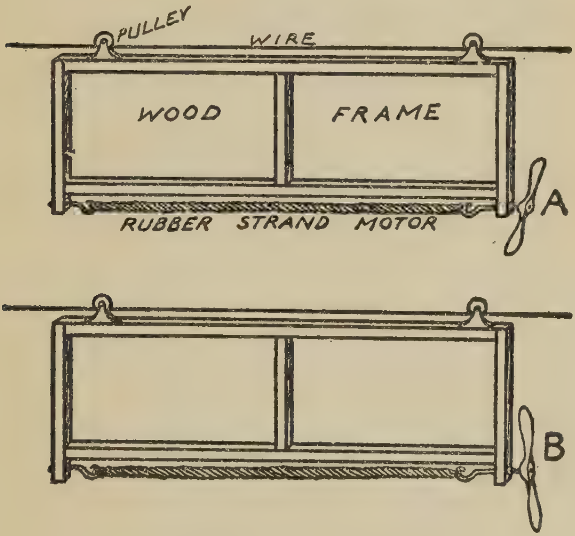


Fig. 100.— Propeller Testing Device

the same number of turns, the frames were raced against each other. By changing the propellers from one frame to the other and checking up the results it was easy to find the propeller that was most efficient. By using known propellers the efficiency of rubber motors can be tested out in the same way. Try it and you'll learn something.

## CHAPTER IX

# MAKING A COMPRESSED AIR ENGINE AIRPLANE

To drive a model airplane with an engine instead of with a rubber-strand motor both the airplane and the engine must be light and the latter must develop a good deal of power.

The lightest type of an airplane that you can make is the flier described and pictured in Chapter IV and the most powerful kind of an engine for its weight that you can use is a compressed air engine, hence this is the one I shall tell you how to build.

**A Word About Engines.**— In making a compressed air engine just bear in mind that any engine built to run with steam will run equally as well with compressed air and the other way about; this being true it stands to reason that the underlying principle of both are exactly the same, that is, the power is developed by the direct pressure and the expansive force of steam or compressed air on a piston in a cylinder.

A compressed air power unit can be made lighter than a steam engine plant in virtue of the fact that the former needs only a tank to hold the air while the latter requires a boiler and heating arrangement of some kind to generate steam and this means added weight for fuel and water. From this you will see that there is a greater saving in weight by using compressed air as the motive power but of course the power will not last as long as that developed by a steam boiler.[1]

Now while the compressed air and the tanks which I shall tell you how to make are of very light construction don't get it into your head that anything you put together will work good enough to drive your flying model. Far be it from such, for if they are to work efficiently, to develop the power needed, all parts of them must be made to fit airtight and the moving parts must be made to work with as little friction as possible.

You will see from the drawings shown at Figs. 101 and 102 that the engine is made a little differently from an ordinary slide valve steam engine in that the engine has two opposed cylinders and the energy of the air is applied alternately to one end of each of the pistons, hence in effect it develops power as though it was of the ordinary type of steam engine having a single cylinder.

The rotary valve does away with the *eccentric* which is used with a *slide-valve* in a steam engine and this makes the compressed air engine more simple, easier to make, reduces the weight and lessens the friction.

**How to Make a Compressed Air Engine.**— To get the most power with the least friction this little model engine is designed with *opposed cylinders,* that is with two cylinders set 180 degrees apart, or in simpler language, in a straight line, and their pistons connected to a crankshaft which sets between them as shown in the accompanying drawings.

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[1] For working models of steam and gasoline engines see "The Boys' Book of Engine Building," by the present author and published by Small, Maynard and Co., Boston, Mass.

*The Cylinders and Inlet Tubes.*— The cylinders are open at the ends which face each other and are closed at the other and outer ends.

A good way to make the cylinders is to buy a couple of *ferrules* such as are used for fishing rods [2] as these are light, strong and are spun very true. Cut off the open ends with a pair of tinners' snips or heavy shears so that each one will have a length of 1½ inches. Drill a ⅛ inch hole in the center of the head of each ferrule for the compressed air inlet pipe (see Figs. 101 and 102), and then drill a 1/16 inch hole 11/16 inch from the closed end of each cylinder for the exhaust port.

This done, cut off two pieces of copper tube having an outside diameter of ⅛ inch and make them 2½ inches long and then plug up one end of each one and fill both of them with melted lead. When the lead is cold you can easily bend an end of each tube on a round iron rod ½ an inch in diameter and it will not flatten out and choke up the bore as it is likely to do if you tried to bend it when hollow.

After you have bent the tubes hold them over the flame of an alcohol lamp or a Bunsen burner and beat

[2] You can buy these at any sporting goods store.

them until the lead melts and run it out of both. Next fit the end of each tube nearest the bend into the hole in the head of a cylinder; see to it that the long straight end of the tube is exactly parallel with the side of the cylinder and then solder the tube to the cylinder head.

*The Pistons and Connecting Rods.*— Get two more

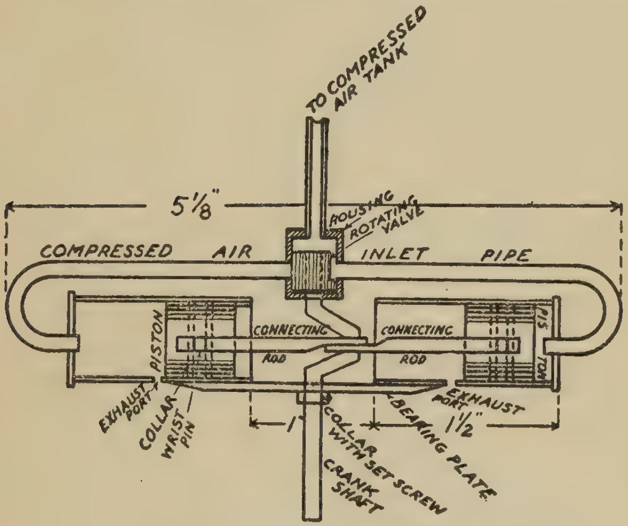


FIG. 101.— TOP VIEW OF COMPRESSED AIR ENGINE

fishing rod ferrules with closed ends which will fit snugly into the cylinders and cut off the open ends so that each will have a length of 9⁄16 of an inch. Fill each one full of melted lead and when the latter is cold drill a ⅛ inch hole through the center of each ferrule, or piston as it is now become as shown at A in Fig. 103. Now melt the lead and run it out.

Next cut off a bit of steel rod ⅛ inch in diameter and ⅝ of an inch long, as shown at B for the *piston pin,* or *wrist pin* as it is often called, that is, the pin that holds the connecting rod in place in the piston. To make the connecting rods, cut off two pieces of 3¼ inch brass tubing 1⅝ inches long and flatten one end of each one as shown at C; drill a ⅛ inch hole in each end so that the centers of the holes in each rod will be exactly 1¼ inches apart.

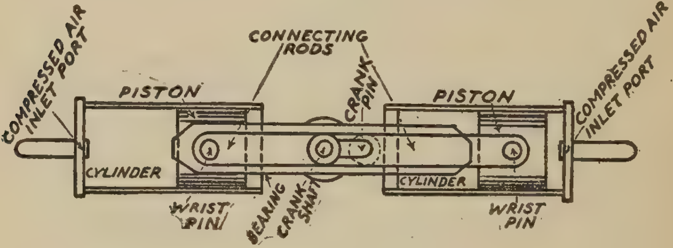


FIG. 102.— SIDE VIEW OF COMPRESSED AIR ENGINE

When you have the rods finished put the wrist pin through a hole in the piston, slip on a wrist pin collar (see D), then put the wrist pin through the hole in the round end of the connecting rod; slip on another collar and, finally, put the pin through the hole in the other side of the piston and solder the ends of the wrist to it.

Now make a grinding paste by mixing a little fine emery — about No. 120 — with a few drops of sewing machine oil; dip a soft rag into it, loop the rag around the piston and rub it evenly all over until it fits nicely into the cylinder. When rubbing the pistons be mighty careful not to bend them out of shape and likewise be sure to get every particle of emery off of them before putting them into the cylinders. Oil the pistons well when they ought to slide forth and back easily in cylinders and yet fit closely enough not to let the air leak past them.

*Forming the Crankshaft.*— This important part of the engine should be made of a piece of soft steel rod ⅛ inch in diameter and 2⅝ inches long and you can bend it either cold or by heating it to the exact size and shape shown in Fig. 101.

Whichever way you do it be sure that the shaft on either side of the *web,* that is the part that joins the shaft to the *crankpin* on which the connecting one coupled, does not get bent or dented and that both ends of the crankshaft are in perfect *alignment,* that is, in a true line with each other.

When you have the crankshaft made slip the flat ends of the connecting rods over it and on to the crankpin with their flat surfaces together so that the round part of the rods will be in alignment as shown in Fig. 101.

*The Rotary Air Valve and Its Casing.*— As the compressed air must be admitted alternately on each piston a valve of some kind is needed to admit the air first to one cylinder, and when the piston in it has reached the end of its stroke, to cut off the air and admit it to the other and opposite cylinder.

This is the purpose of the rotary valve and the way it is fixed to the end of the crankshaft is shown in Fig. 101, and the way it is made is pictured in the top, side and perspective views at E in Fig. 103.

To make it, saw off a piece of brass rod ⅜ inch in diameter, ⅜ inch long as shown in the top and side views at E. Drill a ⅛ inch hole through it from top to bottom in the center and it must be done accurately.

Now file out a piece about ⅓ the circumference of it and ¾ of its length when it will look like the perspective view pictured at E. Thread the part with the hole in it by tapping it out and thread the end of the crankshaft with a die and screw the valve onto it tight.

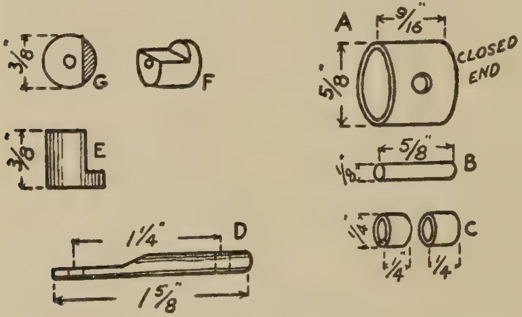


Fig. 103.— Some of the Parts of the Engine

For the air-chest, or casing, as it is called, saw off a piece of brass tube which has an inside diameter of ⅜ inch and make it ½ an inch long. Solder a head on one end of it and then drill a ⅛ inch hole in the exact center of the head and two ⅛ inch holes on opposite sides of the tube ⅛ inch from the head.

Set the rotary valve in the casing, slip a piston into each cylinder, put the end of the crankshaft through the head and screw it into the rotating valve. When you have done these few little things see that the pistons are set in the cylinders as shown in Fig. 101 when you must turn the rotary valve in the casing to the position shown also in Fig. 101 and at the same time it must be tight on the crankshaft.

You are ready now to fit the ends of the air inlet pipes into the holes in the casing and solder them there. Cut out another head for the casing, drill a ⅛ inch hole through the center of it and solder it to the other and open end of the casing and then fit and solder a ⅛ inch brass or copper tube about an inch long into the hole in the head of the casing.

This arrangement not only makes the crankshaft work the rotary valve direct but the latter forms a good bearing for it. The bearing for the other end of the crankshaft is made of a strip of brass 1/32 inch thick, ⅜ inch wide and 2⅜ inches long. Drill a ⅛ inch hole through the middle of this strip and round the ends of it lengthwise to make it fit snug against the walls of the cylinders. Slip the bearing over the crankshaft, hold it in place and see that the shaft will turn without binding and solder it to the cylinders.

Finally cut off a ring of brass tubing for a collar, drill and tap a hole in it and fit in a screw; put the collar on the crankshaft close up to the bearing and screw it tight on the shaft.

All that remains to be done is to oil all the working parts with a good grade of sewing machine oil and try it out. The engine should work easily enough so that when you blow hard into the tube, that is, to lead to the compressed air tank, the crankshaft will make one or two complete revolutions after you give it a little start with your hand.

**How to Make the Compressed Air Tank.**— The tank to hold the compressed air should be made as light as possible and yet be strong enough to hold air when it is under a pressure of 50 pounds or so to the square inch.

An easy way to make a cheap, light and strong air tank is to have a piece of wood turned down to 2½ inches in diameter and 18 or 20 inches long. Next get a strip of very thin sheet copper about 5 inches wide and 2 feet long, or you can rivet and solder a couple of strips together to give it the required length.

Begin by wrapping the strip of copper around the wood cylinder in a spiral and let the edges lap over about ½ an inch as shown at A in Fig. 104. To hold the copper strip in place for the time being, twist three or four lengths of wire around it as shown at B. Now solder the seams all along and you will have to do a good job or else it will not be air-tight.

When you have the seams all soldered drive a tack in each end of the cylinder, twist the end of a No. 16 copper wire around one of them and wrap it around the copper shell so that the turns will be ⅛ inch apart all the way along until the other tack is reached and then fasten it there. Fix the wire to the copper shell by putting a little dab of solder on every quarter of a turn, as shown at C, with your soldering copper. This done, slip the shell off of the wood cylinder and trim the ends off even.

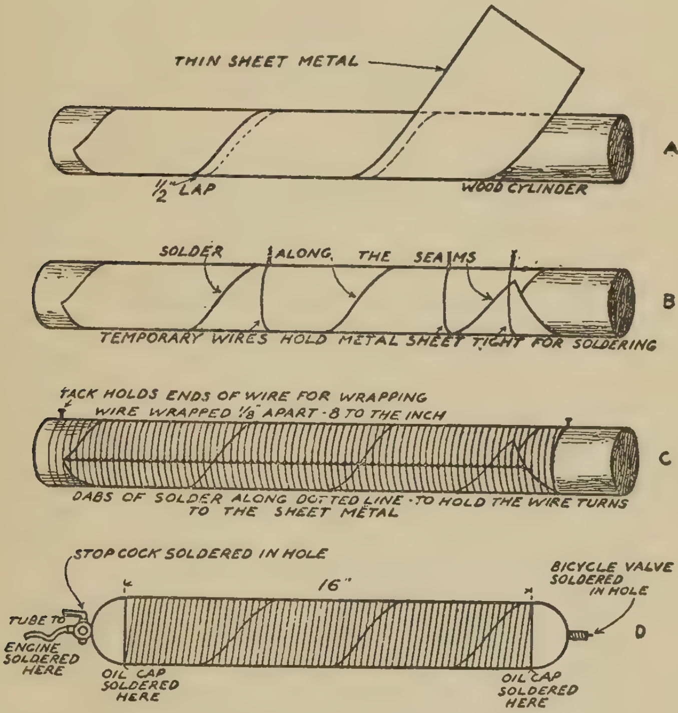

THIN SHEET METAL
1/2" LAP
WOOD CYLINDER
A
SOLDER ALONG THE SEAMS
B
TEMPORARY WIRES HOLD METAL SHEET TIGHT FOR SOLDERING
TACK HOLDS ENDS OF WIRE FOR WRAPPING
WIRE WRAPPED 1/8" APART · 8 TO THE INCH
C
DABS OF SOLDER ALONG DOTTED LINE · TO HOLD THE WIRE TURNS TO THE SHEET METAL
STOP COCK SOLDERED IN HOLE
16"
BICYCLE VALVE SOLDERED IN HOLE
TUBE TO ENGINE SOLDERED HERE
OIL CAP SOLDERED HERE
D
OIL CAP SOLDERED HERE

Fig. 104.— Construction of the Air Tank

For the heads of the tank get two 10-cent sewing machine oil cans 2½ inches in diameter and cut a half inch hole in the bottom of each one. Unscrew the spouts of both, solder a stop-cock in one neck and a bicycle valve in the other as shown at D. Now solder the ends of the shell to the bottom of the oil can when the tank will be complete and look like E.

Different from a steam engine and boiler, which must be placed as closely together as possible in order to convert all the energy that is in the steam into power, an engine worked by compressed air can be set any distance from the tank since heat is not a factor in developing power.

To connect the tank with the engine use a piece of rubber tubing of whatever length may be necessary and fit one end over the outlet pipe of the stop-cocks and the other end over the inlet pipe of the engine. To keep the tube from being blown off you can wrap a few turns of wire around the ends and twist them up tight.

**To Fill the Tank With Air.**— It is a very simple matter to fill the tank with compressed air for all you have to do is to connect a bicycle air-pump, or, better because it is larger and more powerful, a motor-car air pump, to the valve, turn off the stop-cock and pump away just as though you were inflating a tire.

**To Start the Engine.**— To start the engine turn on the stop-cock and give the crankshaft a couple of turns with your hand. The compressed air will then flow into the rotary valve casing and thence into the cylinders where the pressure of the air acting on the piston drives them forward and this makes the connecting rods rotate the crankshaft.

It is easy to start the engine when you have it mounted in your airplane and the propeller fixed to the end of the crankshaft as this gives you the leverage needed to turn the latter over.

**How the Engine Works.**— Now let's go a little more into detail as to how the engine works. When the compressed air is turned on at the tank it flows into the casing in which the rotary valve works.

As part of the valve is cut away (see Fig. 101 and E in Fig. 103), when either one of the pistons is at the closed end of its cylinder the valve is brought to such a position that the air can flow freely through the inlet pipe connected with that particular cylinder. At the same time the solid part of the valve closes up the opposite inlet pipe.

As the pressure and expansion of the compressed air drive the piston toward the open end of the cylinder the connecting rod pivoted to the piston and to the crankshaft forces the latter to turn a half revolution. When the piston has reached the end of its stroke the head passes over a small opening in the cylinder, called the exhaust port when the used air passes out of it and into the open air.

At the same time the crankshaft is turning over it rotates the valve a half revolution so that the part that is cut away now faces the opposite inlet pipe and an open passageway is formed through which the compressed air can flow into the cylinder and acts on its cylinder and another half revolution of the crankshaft is made. The cycle of operations then begins all over again.

**Mounting the Tank and Engine on the Airplane.** — Make a strong flier as described in Chapter IV with fore and aft planes like those of the Blériot model. Mount the engine crosswise on the rear part with the cylinders inside the frame close up to the metal cross-bar and wire or otherwise fix them together so that the engine is held perfectly rigid.

Mount the compressed air tank on the frame by putting the band under the end nearest the engine and a band over the end nearest the nose and screw the ends of the bands to the frame. Connect the outlet pipe of the tank with the inlet pipe of the engine. Finally connect up a 10-inch propeller to the crankshaft of the engine, all of which is shown in Fig. 105.

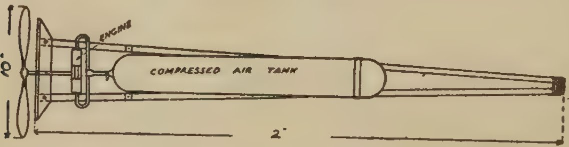
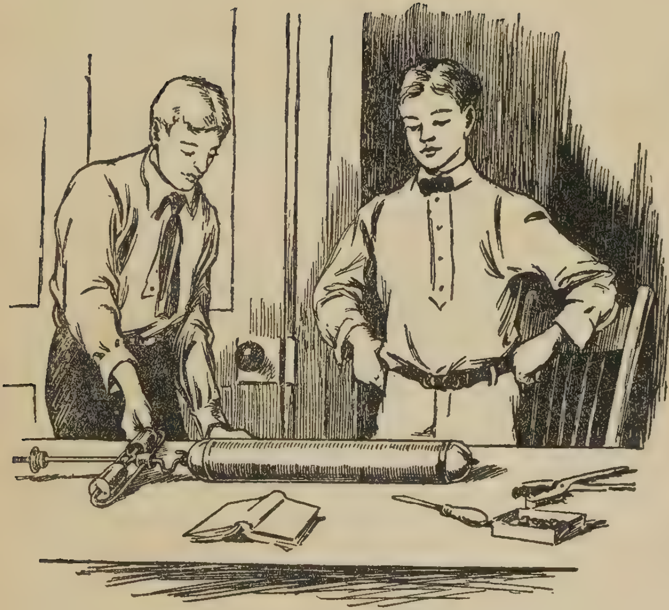


FIG. 105.—THE ENGINE AND TANK ON THE FRAME OF THE FLIER

To fly the airplane hold it up as shown in Fig. 43, turn on the stop-cock, give the propeller a turn, then gently shove the airplane from you and let it go at the same time and the trick is done.



The Compressed Air Engine Complete.

## CHAPTER X

## BUILDING A BOY-CARRYING GLIDER

After you have built and flown a model or two you will wish deep down in your heart that you might take a little flier yourself — that is if you could do it safely and at a small cost.

Presto! no sooner thought of than done, for if you will build the glider described in this chapter you can do both and the experience you will get in gliding with it will be of much value to you should you ever want to learn to fly in a real airplane.

Now a glider is really nothing more than a kite big enough to lift you and nothing less than an airplane without the motive power. There are two ways to make it lift you off of the ground, the first of which is to hold it over your head and with the help of two or three pals run down hill against the wind when the speed will soon be enough to lift its outstretched planes and it will carry you a-sailing through the air.

The second way is to hitch your glider to a horse, or better to a motor car — a star will not do — and when the antediluvian quadruped or precursor of the airplane gets up speed your glider will fly like a kite and away it will sail into the air and carry you along with it just as though you had a motor in it.

**Materials Needed for the Glider.**— *Wood.*— All of the wood should be of good, straight-grained spruce, and there should not be any knots in it. After you have picked it out have it sawed to size and planed smooth at the woodworking shop as this will save you a lot of hard work and costs but little more than to buy the boards in the rough.

For the front and the rear spars get:

(a) Four strips ¾ inch thick, 1½ inches wide and 18 feet long. If you can't get the strips in 18 foot lengths take two 9 foot lengths and with an extra piece 4 or 5 feet long, bolt them together.

(b) Twelve *struts* ½ inch thick, 1 inch wide and 2 feet 9 inches long; these are to hold the spars of the frame together.

(c) Twelve *stanchions* 1 inch in diameter and 3 feet 6 inches long, or these may be made of ¾ inch square stuff with the sharp edges planed off.

(d) Two *arm rests* ⅞ inch thick, 2 inches wide and 2 feet 9 inches long.

(e) One *cross-bar* ½ inch thick, 1½ inches wide and 3 feet long.

(f) Thirty-seven *ribs* ½ inch square and 3 feet 9 inches long.

(g) Two *outriggers* 1 inch thick 1¼ inches wide one of which is 9 feet long and the other 10½ feet long.

(h) Two *vertical sticks* for the side supports of the direction rudder ¾ inch thick, 1 inch wide and 3 feet 3½ inches long.

(i) (a) Two *end sticks* for the *elevation* plane ¾ inch thick, 1 inch wide and 2 feet and 6 inches long; (b) two *side bars* ¾ inch thick, 1 inch wide and 5 feet long, and (c) two *struts* for the middle on which to tack the muslin, ¾ inch thick, 1 inch wide and 2 feet 4½ inches long.

*Metal Fittings.*— (a) Two dozen *iron sockets* having a 1 inch bore so that the ends of the stanchions will fit into them.

(b) Four dozen *eye-bolts,* ¼ inch in diameter and 2¼ inches long with a washer and two nuts on each one.

(c) Two dozen *copper* clamps, to hold the struts to the spars. These can be made of soft sheet copper ⅙ inch thick, cut into strips ¾ inch wide and these again into pieces 4 inches long.

(d) Thirty-seven *copper* clamps to hold the ribs to the spars. These are also made of soft sheet copper 1/32 inch thick, cut into strips ½ inch wide and 2½ inches long.

(e) Five dozen round-headed wood screws No. 30, 3/16 inch in diameter and ½ inch long to fasten down the above clamps.

(f) Copper strips are also used as straps to fasten the corners of the frames of the rudder and the elevation planes, and the outriggers to the main planes.

(g) (1) Four *iron bolts* for the arm rests ⅜ inch in diameter and 2 inches long with two washers and two nuts on each one; (2) four *bolts* ⅜ inch in diameter and 2¼ inches long with two nuts and two washers on each one to fasten the outriggers to the struts and spars.

(h) About one hundred brass sleeves for holding wire in place made of brass tubing with 1/16 inch walls, 1/4 inch in diameter and 1/2 an inch long.

(i) One-half dozen small steel *turnbuckles* for tightening up tail wires.

(j) A roll of 200 feet of No. 16 tinned *steel wire* for cross bracing the plane cell and guying out the tail.

(k) Two pounds 10-penny *wire nails* to fasten the struts and spars together; the ribs to the spars and the sticks forming the rudder and elevation planes.

(l) Four boxes of upholsterer's *tacks* for tacking the muslin to the spars and ribs.

*Fabric.*— Twenty-five yards of closely woven unbleached *muslin* will be enough to cover the main planes and the tail planes.

*Tools.*— A hammer, miter-box and hand-saw, a hack-saw, brace and bits, smoothing planes, an awl and a few carpenter tools will be all you need to *assemble* or put up the glider.

*Assembling the Glider.*— Before you begin the work you must make up your mind whether you will make all of the joints lap-joints or simply lay one stick on the other and nail it there. A lap-joint or partial lap-joint, wherever one can be used, will make a much stronger glider but an ordinary joint bound with a copper strap or clamp will serve the purpose and it is a good deal easier to make.

Begin the work by laying out the frames for the main planes. Lay two of the spars on the floor and have them 2 feet 9 inches apart; nail a strut across them 1 inch from the ends as shown in Fig. 106. Nail on the next pair of struts 3 feet 11 inches from those on the end and the next and middle pair 3½ feet from the second pair; this will bring the two middle struts 3 feet apart.

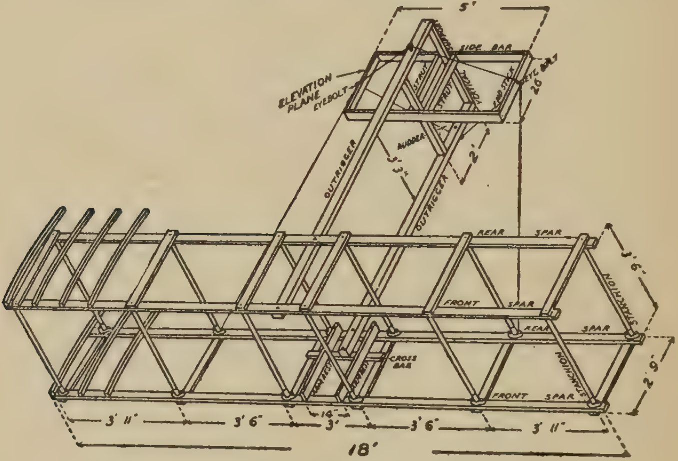


Fig. 106.—The Frame of the Glider Complete

Now make all of the large copper clamps as shown at C in Fig. 107 and drill holes through the ends exactly even with the eyebolt holes in the socket; having finished these, screw a socket down right over each strut on the other side of the spar; when all of them are screwed down drill holes through the spars even with the eye-bolt holes in the sockets as shown in Fig.

107B; the next thing is to push an eye-bolt through each hole in one of the sockets, put a copper clamp over the strut with the ends of the eye-bolts projecting through the holes, slip on a washer and screw up both nuts tight.[1]

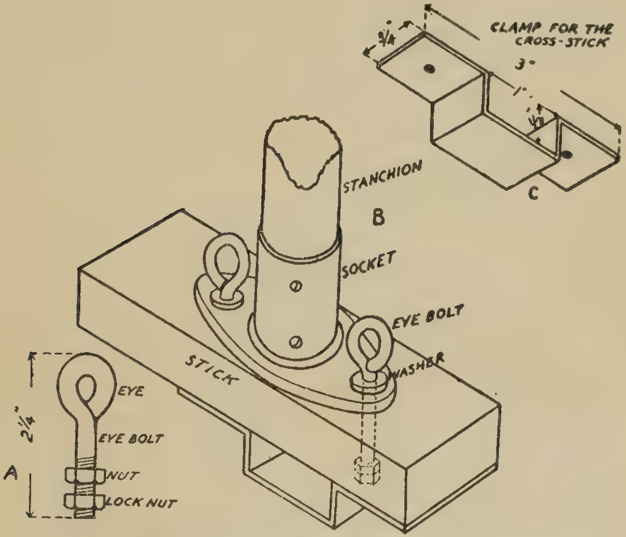


FIG. 107.—HOW THE STANCHION IS FIXED TO THE STICK

Now bore a hole through each end of both of the two arm rests and countersink the holes on top so that the heads of the bolts will sink below the surface of the wood, and bolt the arm rests 12, 13 or 14 inches apart, depending on the width of your body, to the front and rear struts. Under the arm rests and on top of the middle struts set your cross-bar (see Fig. 106), and screw it fast to these pieces.

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[1] The second nut is called a lock-nut as it keeps the first from working loose.

The ribs are next in order. You can make your glider with straight ribs but its balance will be much better and its lifting power greater if the ribs are slightly curved as shown at A, Fig. 108. The best way to bend the ribs is to steam them but you will need a tin boiler a foot longer than an ordinary washing boiler to do it.

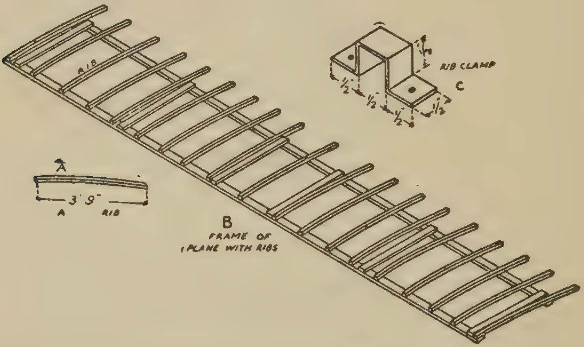


Fig. 108.—The Frame of the Upper Plane with Ribs

An easier way is to soak the ribs in boiling water and then bend them in a form of large nails driven in a board, just as you did in making the ribs for the models, and let them dry over night.

When all of the ribs are bent begin by nailing one at each end of the upper plane and one in the middle. To keep them from splitting, drill a hole through the end and part where they are to be nailed to the spars.

Nail on a rib just outside of the two middle struts as shown at B in Fig. 108 and then nail on the other ribs so that the spaces between them are equal. The ribs, it will be seen, project a foot over the rear spar.

Nail the rest of the ribs to the lower frame in the same way. Of course there is no room for a rib between the arm rests and this divides the lower plane into two panels. Each one of the ribs is further secured to the spars by putting on a small copper clamp, as shown at C in Fig. 108, over the ends and screwing it down to the spar.

*Covering the Main Planes.*— Cut the muslin into 4-foot lengths and sew 7 lengths together with lap seams making a cover 4 feet wide and 21 feet long; cut enough from one end to make it 18 feet 3 inches long. Fold the edges over 1 inch all round and fold it again until the width is 3 feet 8½ inches wide, and sew it.

Tack one edge on the under part of the front spar with upholsterer's tacks every 2 inches; now stretch the muslin until the trailing edge comes to the rear ends of the ribs and tack it to each one in turn; drive a tack every 2 inches in the ribs and you will have a covering that will do.

For the lower plane cut the muslin into 4-foot lengths as before and sew enough strips together to make two pieces 7 feet 9 inches long. At the places where the sockets come, cut out holes and hem them well so that the muslin cannot tear. Tack the pieces of muslin to the under side of the front spar and draw it over the top of the ribs with the stanchion sockets projecting through the holes.

Now you can set the stanchions in the sockets of the lower plane and set the other and upper plane on top of them so that the ends of each one will fit into its own socket. A hole is already drilled through the collar of each socket and drill a hole of the same size through the stanchion when you can push a ¼ inch bolt through both of them and screw on a nut. This completes the plane cell.

*Making the Tail.*— The tail is formed of two flat planes set at right angles to each other. The horizontal plane while it is marked *elevation plane* is fixed in place and serves not only to keep the glider balanced lengthwise but to cause it to ascend or descend when you swing your body to and fro. The vertical plane, though marked rudder is also fixed in position and is used chiefly to keep the glider balanced sidewise though it causes it to turn a little when you swing your body to the right or left.

In engine driven machines as you will presently see, the rudder and the elevation planes are hinged so that they can be moved or *controlled* as it is called by the pilot; but this is not necessary with a glider for as I have just said, the elevation can be controlled to a small extent by the swinging movements of the flier's body.

*The Elevation Planes.*— Make these planes first by nailing the 2½ foot pieces to the 5-foot pieces and nailing a pair of struts in the middle, leaving a space of 2 inches between them for the vertical supports (see Fig. 106), to slip through. Put a strap of sheet copper around the corners and screw them fast to hold it firm. Drill a hole through each end of the end sticks, put in an eye-bolt and screw on a nut. This done tack muslin on both sides of the frame and the struts.

*The Rudder.*— Now slip the vertical supports of the rudder through the slot between the elevation planes and then nail the two outrigger beams to them and fasten them with copper straps as in the case of the elevation planes. Drill a hole through the outrigger inside of and close to the vertical sticks, put in an eye-bolt and screw on a nut.

Cover both sides of the rudder with muslin, drawing it down through the slot between the struts of the elevation planes and tacking it on nice and smooth. Bore holes in the ends of the outriggers at the places where they meet the cross-bar and front spar and where they cross the rear spars and fasten them on with bolts.

*Bracing the Glider.*— There is one more thing to do and you must do it well for you are not playing with models now — you're out of that class — and that is to cross-wire the plane-cell, that is, you must brace it with wires and also guy out the tail with wires to make it rigid.

To cross-wire the main cell, take a length of tinned steel wire, or piano wire, and slip one of the brass sleeves over an end; push the end through the eye of the eye-bolt of a stanchion socket, pass the end of the wire through the sleeve again and bend it over as shown at A, Fig. 109.

Slip another sleeve on the other end of the wire, loop it through the eye of another bolt, thread it through the sleeve again and draw it up tight; bend it back over the edge of the sleeve and cut it off. Keep on cross wiring the plane-cell in the same way until every section is braced with eight wires running in as many directions.

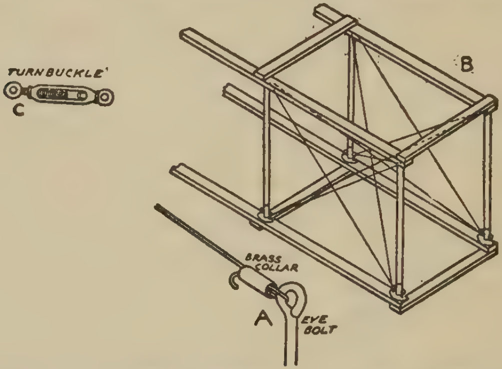


FIG. 109. A.—THE EYE-BOLT. B.—CROSS WIRING THE FRAME OF THE GLIDER. C.—THE TURNBUCKLE

After the planes are wired together take a wire and starting at one of the eye-bolts in the elevation plane fasten it to an eye-bolt in one of the outriggers; bring it on down to the eye-bolt on the other side of the elevation plane, then on down to an eye-bolt in the lower outrigger and back to the eye-bolt you started from. Wire the other end of the rudder and the elevation plane the same way.

Last of all, fasten two turnbuckles as shown at C, Fig. 109, to each forward eye-bolt on the tail, double over four lengths of the steel wire and fasten the end of each of them to one of the eye-bolts in the top and bottom sockets of the second rear stanchions from the ends of the plane-cell; bring these four doubled wires over to the tail and fasten each one to a turnbuckle and draw them up tight. Guy out the tail by doubling over four lengths of the steel wire and fasten the end of each length to a top and bottom eye-bolt as before and fix these wires to the turnbuckles on the ends of the elevating planes. The purpose of the turnbuckles is so that you can tighten or loosen the wires as you please and so true up the tail.

The whole glider must be put together strong and crosswired right so that when it is hit by a little gust of wind it will not bend all out of shape and fix it, as Uncle Remus would say so that " somfin's gwine to drap."

*Sliding Down a Hill of Air.*— Believing now that your glider is fit and ready and that you are ready and fit to glide in it, let's find out how to do this thing that aviators call gliding and what's more let's find out how to do it safely.

To handle your glider you should have a couple of friends to help you and these will be easily found for wherever there is a glider every fellow who can scotch the time will be on hand to help you and if not this, then to get in your way. But bear with him gently, son, for he is just as much interested in flying as you are, though he may not be lucky enough to own a glider.

Begin by taking your glider into a level field on a still day; have a man or two hold up the ends of the plane cell and another to hold up the tail. Stand with your body between the arm rests and your hands on them; when you are ready give the signal to your henchmen and starting off on a dog-trot gather speed until you are running as fast as you can and the faster you run the lighter will grow the weight of the glider.

When you can no longer keep your feet on the ground signal the fellows to *let her go,* hang on with your arms, draw up your legs and away you will glide — for a few feet but it's a joy ride while it lasts.

Practice these short glides until you have learned how to balance the glider by throwing your legs forward when you want to go up and drawing them up back of you when you want to go down and from one side to the other when you want to balance it sidewise or to turn a little.

When you have become fairly proficient in balancing the glider take it up the gentle sloping side of a hill and you and your friends run with it down hill. You will be surprised to find how far you can glide with it with this kind of a start and how easily you can make it sail up, then down, then up again by kicking your legs out before you or drawing them up behind you.

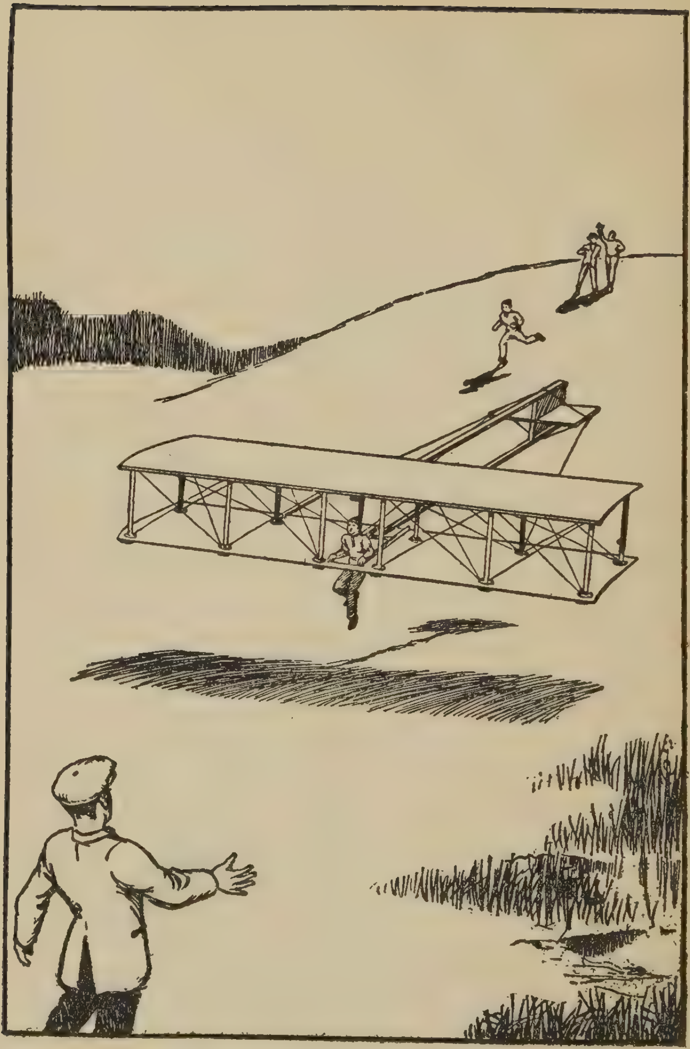
To glide safely follow these rules:—

(1) Never attempt to glide when the wind is blowing more than 10 or 15 miles an hour, that is, more than a light breeze.

(2) Do your gliding on a gently sloping hill and keep near the ground.

(3) Always fly against the wind for a gust striking it head-on will only make it rise higher but if it strikes it rear-end-on it will tend to pitch it to the earth.

(4) Never try jumping off from a house-top or a bank because there is a sudden reaction of the air and instead of gliding the machine is almost sure to take a sudden drop.



THE GLIDER IN THE AIR

## CHAPTER XI

## ABOUT REAL AIRPLANES

If you ever build the glider described in the last chapter and make some flights in it you will quickly see great possibilities if the thing was fitted with the proper controls, an engine and a propeller.

But when this is done it means that you will have a full fledged airplane — a contrivance that is no longer a toy but a powerful machine on whose design, construction and management your very life hangs literally in the air.

**The Design of Airplanes.**— *General Types of Machines.*— Man-carrying airplanes have the same general lines as the scale models that have gone before and as you learned from them there are two general types of machines and these are (1) *monoplanes,* or those having a single main plane like the Blériot, and (2) *biplanes,* or those having two planes one above the other, or *superposed* as it is called, like the Wright. As the latter are the strongest nearly all machines now built are of this type.

These two types may be divided into two general classes and these are (1) *tractor airplanes,* that is, those having their propellers in front and which *pull* the machine along as in the Blériot monoplane, and (2) *pusher airplanes,* that is those which have their propellers back of the main plane and *push* the machine forward as in the early style of Wright biplane. Practically all of the machines now built are of the tractor kind.

*The Fuselages or Bodies.*— The bodies of airplanes are long and slender and they have to be built very strong for they form the backbones of the machines in and around which the other parts are placed.

The main planes are set forward on the bodies, the elevation and direction rudders are set aft on them while the engine, where only one is used, and the seating section for the pilots and their companions are placed in the fore end of the bodies. The landing gears, when these are used, are fixed to the under fore part of the bodies. From this you will see that the heads of the machines are very much heavier than their tails and the purpose of this will be made clear presently.

The bodies are covered all over, except the upper part of the seating section, to lessen as much as possible the resistance of the air.

*The Main Planes.*— These planes are built up of ribs that are curved, or *cambered* as it is called, so that the plane curves sharpest at the *leading edge,* that is the front edge and the ribs are held in place in a frame as you have learned from the models.

The framework of these planes is covered on both sides with linen coated with *dope*[1] or rubberized fabric, either of which is impervious to the air. The upper and lower planes are joined together with *stanchions,* that is, upright supports, made of oval sectioned wood, which offers the least resistance to the wind, and they are further strengthened by cross stays of steel wire.

The planes are then fixed to the bodies of their respective machines at a slight angle to the former, called the *angle of incidence,* that is, the leading edges set a little higher than the trailing edges of the planes.

*The Elevation and Direction Rudders.*— The *elevation planes,* which are really rudders for steering the machines up and down, are placed, in present day machines, on the tails of the latter and it is the usual practice to make them straddle the direction rudder as in the model of the Curtiss flying boat described in Chapter VII.

The elevation rudders, of course, set on the machine parallel with the surface of the earth while the direction rudders set at right angles to the earth's surface just as they do when used for steering boats.

*The Controls That Are Used.*— The *control* in general use on all machines is the type known as the *Deperdussin,* or just *Dep.* as it is called for short.

This control, which is shown at A and B in Fig. 110, consists of a steering wheel, like that of a motor car, which turns the direction rudder from side to side, and a steering post which moves the elevation

[1] This is a varnish used for coating the wings of airplanes.

rudders up and down. The steering wheel turns in the upper part of the steering post and the latter is pivoted near its lower end. Finally the wheel and the post are connected cables which run over pulleys to their respective rudders.

To steer the airplane then all you have to do is to turn the wheel so that the top of it moves to the right or left according to whether you want to go right or left in the air and push the wheel out or pull it in when you want to go up or down, since it is attached to the post. With this control, steering an airplane becomes just as natural as steering a motor car.

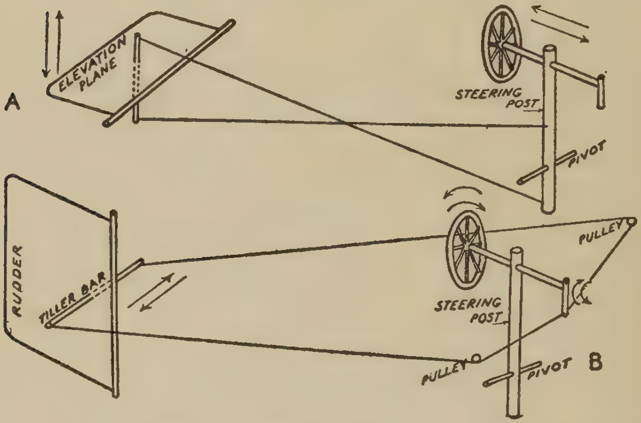


FIG. 110. A.—"DEP." CONTROL SHOWING UP AND DOWN STEERING. B.—"DEP." CONTROL SHOWING DIRECTION STEERING

In instruction machines two wheels and two posts are linked togeher so that the instructor as well as the pupil is in control of the machine and either one can steer it.

*Kinds of Airplane Engines.*— The only type of engine that has been found light and powerful enough for airplane propulsion is the *gasoline engine.*[2]

There are, however, two general kinds of gasoline engines used for airplane work, namely, those with (1) *fixed cylinders* and (2) *revolving cylinders.* Engines with fixed cylinders have their cylinders set either vertically, or forming a V angle as shown in Fig. 111. The now famous Liberty motor is an engine of the V kind and has 12 cylinders. A revolving-cylinder engine is shown in Fig. 112.

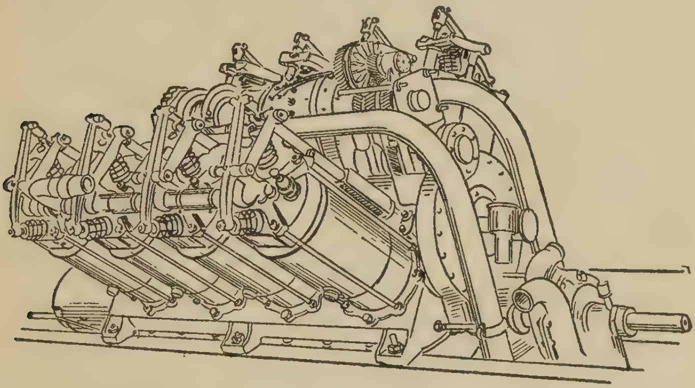


FIG. 111.— A V-TYPE AIRPLANE ENGINE
*(From "How to Fly" by A. F. Collins. Courtesy of D. Appleton and Company)*

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[2] For a description of various airplane engines see "How to Fly," by the present author and published by D. Appleton and Co., New York.

*The Starting and Alighting Gear.*— Machines that are made to rise from and alight on the ground are provided with *running gears.* These are fitted with heavy and strong pneumatic-tired wheels and are often provided with powerful steel springs which further absorb the shocks.

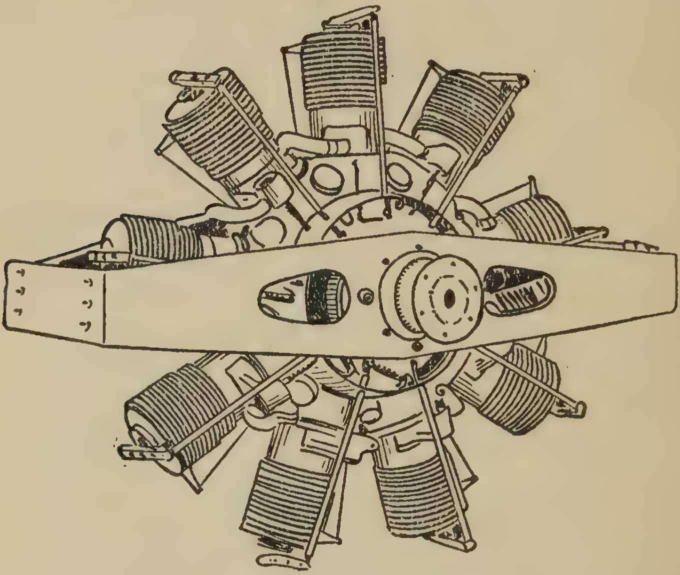

FIG. 112.— A REVOLVING-CYLINDER ENGINE
*(From "How to Fly" by A. F. Collins. Courtesy of D. Appleton and Company)*

**The Balance of Airplanes.**— The hardest part about designing airplanes is to give them the right *balance.* Now an airplane must be made to balance in two directions and these are (1) *sidewise,* that is, from side to side, or *laterally* as it is called and (2) *lengthwise,* that is, fore and aft, or *longitudinally* as it is known.

Then there is a third kind of balance and that is around a *vertical center* but this has to do with the pilot more than with the designer. These different kinds of balance, or *equilibrium* as it is called, all depend chiefly on (a) the *center of gravity,* (b) the *center of pressure* and (c) on the *line of thrust* of the propeller (see Fig. 113), and these three factors should meet at the same point. This being the case let's find out just what all these three factors mean in common, every day English.

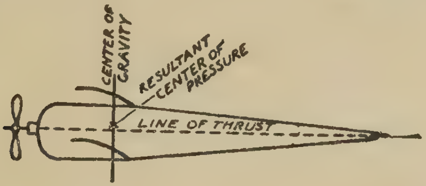

FIG. 113.— THE FACTORS THAT MAKE FOR BALANCE

*What Lateral Balance Means.*— If you will draw a line, real or imaginary, through an airplane lengthwise it is clear that half of its weight will be on one side of the line and half on the other side as shown at A in Fig. 114, that is, the pull of gravity will be equal on both sides as long as the machine is flying on an even keel and the pressure of the air is the same on both sides of the plane or wing.

Hence it does not take much ability to design and build an airplane that will have a natural lateral balance but when you are learning to fly it takes a lot of skill to make it keep its lateral balance.

*What Longitudinal Balance Means.*— Since most of the weight is on the forward end of an airplane, to make each end weigh the same you must draw the line not across the middle of it but well toward its nose as shown at B.

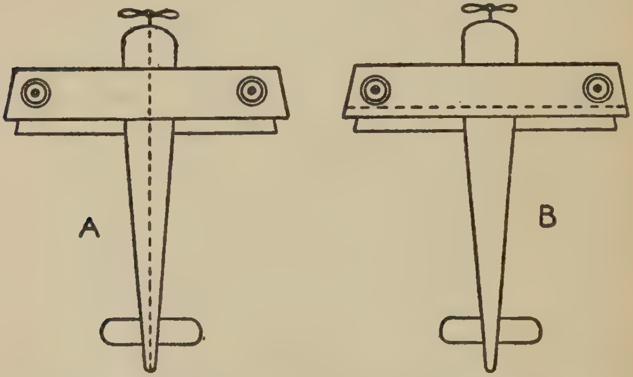

FIG. 114. A.—THE SIDEWISE BALANCE OF AN AIRPLANE
B.—THE LENGTHWISE BALANCE OF AN AIRPLANE

To determine this point, which is called its center of gravity, when designing an airplane is a pretty hard thing to do, but it is important to know exactly where it lies before the machine ever leaves the ground and so after it is built it is *weighed up* to make sure of it.

On the other hand it is quite easy for a pilot to balance his machine fore and aft, that is longtitudinally, and yet when the center of gravity gets too far out of line with the center of pressure he is apt to fall in a nose-spin or a tail-spin if he is not an expert flier.

*On Gravity and the Center of Gravity.*— You can easily demonstrate this principle by making the following experiment: open the blades of two pocket knives of equal weight, stick them into the opposite sides of a cork and push the point of a pin or a needle into the center of the bottom of the cork.

Set the head of the pin or needle on a cork in a bottle when the *system*, as the arrangement would be called in physics, will keep its balance in the most amazing manner. The center of gravity is in a line joining the free ends of the knives and consequently *under* the pin or needle that is below the point of suspension. When a body is thus balanced it is said to be in *stable equilibrium.*

To understand the action of gravity under varying conditions cut out a disk of cardboard, say, 6 inches in diameter and pivot it in its center to a stick or other support as shown in A, Fig. 115. It will, of course, have no tendency to move, for the center of gravity and the point of suspension are at the same place and hence it is in *neutral equilibrium,* as it is called, which means that it is perfectly balanced.

Anything that has weight and which is not supported in the air will fall to the ground as we say. As a matter of fact it does not fall but it and the earth are attracted mutually to one another and because the earth is so much larger than the object the latter is drawn to it.

The force that attracts the earth and every other body on or near its surface to it is called *gravity*. This force, or gravity, always acts in a vertical direction, that is, toward the center of the earth as shown by a plumb line which is represented in Fig. 116.

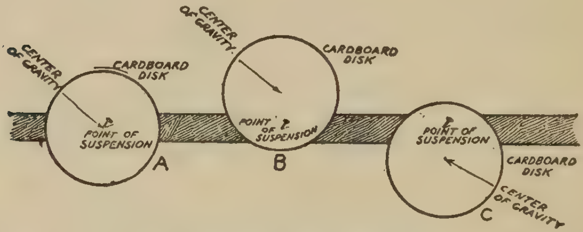

FIG. 115.—HOW GRAVITY ACTS ON A SUPPORTED BODY

Now since every part of an object, or body, has weight and the different parts of it are drawn to the earth by the lines of gravitational force the sum of all of these lines of force act as though they were a *single force* and hence make the object or body act as though these forces were concentrated at a given point; this point is called the *center of gravity* and the object or body can be balanced at this point.

Next pivot the disk to the support below the center of gravity as shown at B, Fig. 115. When the disk is in this position it is said to be in *unstable equilibrium* and the moment you let go of it it will turn over to the position shown at C. The center of gravity is now below the point of support just as the balancing knives were, that is the disk is in *stable equilibrium.*

From these simple experiments it would seem that an airplane should have a low center of gravity but when one is built this way it rocks to and fro sidewise, or oscillates as it is called, when it is flying. On the other hand when the center of gravity is high it flies well but, following the action of the disk at B, when a landing is made it is very unstable and unless the craft is handled with skill it will roll over.

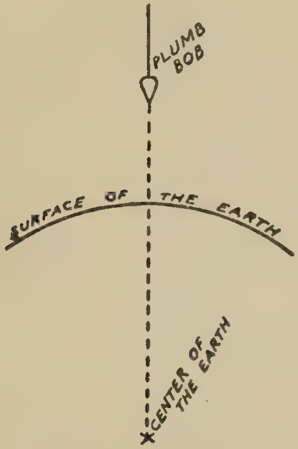

FIG. 116.—GRAVITY ALWAYS PULLS TOWARD THE CENTER OF THE EARTH.

Hence airplanes are designed with their centers of gravity about half way between the extremes of stable and unstable equilibrium, that is having a neutral equilibrium.

*How to Find the Center of Gravity of a Model Airplane.*— To find the center of gravity of your model airplane tie a nail or weight to a string and secure the string to the main plane with sealing wax as shown at A, Fig. 117. Now repeat this operation, securing the string to the chassis near the tail plane as shown at B. Note where the weighted portion of the string falls in each case, and you will find that in the positions shown there is an intersection as shown at C. This is the center of gravity.

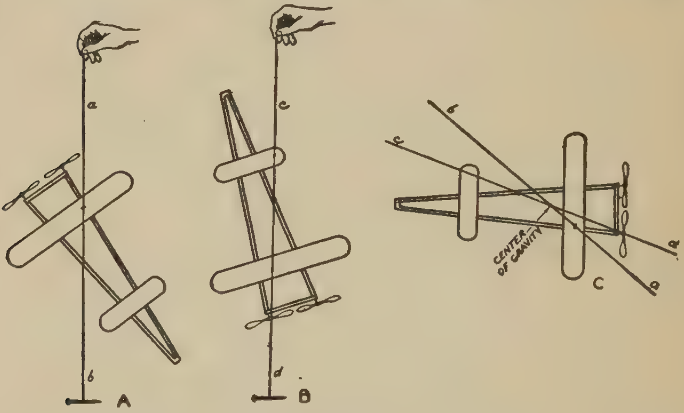

FIG. 117.— HOW TO FIND THE CENTER OF GRAVITY OF A MODEL AIRPLANE

*About the Center of Pressure.*— When the wind blows on a kite or other surface the lines of air press on all parts of it in much the same way that gravity pulls on all parts of a body. Like gravity, too, the pressure of the air acts as though the lines meet at a given point, that is, as though the air was blown in a blast on one spot only and this is called the center of pressure.

Now while the center of gravity in a body is always in the same place whatever may be its position the center of pressure shifts from one point to another according to the angle the surface of it makes with the wind. If you will make the following experiments you will know not only what is meant by the *center of pressure* but how it changes its position every time an airplane noses up or down when it is flying.

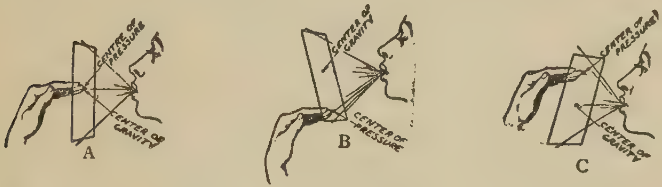

FIG. 118.—AN EXPERIMENT SHOWING THE CENTER OF PRESSURE

First hold a card by its lower edges with your right hand and place the tip of your index finger of your other hand in the center of the back of it as shown at A in Fig. 118. Now blow strong and steady against the face of the card and let go of it with your right hand when, you will find, the stream of air will hold it against your finger. This shows that the center of pressure is in the center of the card as shown at A.

Next hold the card by its upper edges with your right hand and place the tip of your left forefinger against the back of the card near the bottom of it as shown at B. Now blow against it and it will stick to your finger as before but not until it has taken about the angle as shown at B.

Finally hold the lower edges again with one hand and place the tip of your finger of the other near the upper edge of the card and blow, brother, blow, when you will observe that the card will stick as in the foregoing trials and also that it will slant the other way; this is the direction of the slant that the planes of a machine make.

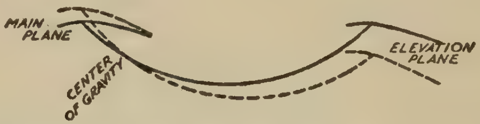

Fig. 119.—How Fore and Aft Balance Is Naturally Maintained

*The Center of Gravity Plus the Center of Pressure.* — It is only when the center of gravity and the center of pressure are in a line with each other that the machine keeps its lengthwise balance best.

To make it do this *auxillary planes,* which are usually the elevators, are fixed to the tail of the machine and the longer the fuselage of the airplane the smaller the auxillary planes need be because the leverage is greater.

You will gather what I mean from the diagram shown in Fig. 119. When the machine is flying the air strikes the under surface of the main plane and tends to lift it up; this makes the airplane turn on its center of gravity when the auxillary plane goes down.

The result is that both the main and the auxillary planes offer a larger spread of surface to the air and this checks and slows down the machine as the fore end is the heaviest and so it drops down. This brings the auxillary plane up and the exposed surfaces of both are lessened and the machine tends to going up again. By these varying pressures the lengthwise balance is maintained automatically.

*The Line of Propeller Thrust.*— This is the line the propeller shaft would have if it was projected on through the machine as shown by the broken line in Fig. 119. This diagram also shows the position of the center of gravity and the resultant *center of pressure* which is the point where the various centers of pressure would come if they acted on the machine at the same time.

## CHAPTER XII

## THE WAY AN AIRPLANE FLIES

It is not so very long ago, that is to say, just before the Wright Brothers made their first successful flights, that there were some folks who opined a heavier-than-air machine could never be made to fly.

The way they looked at it, I suppose, was that the air is so light and an airplane is so heavy that flight by this means was quite impossible but where most of them fell down was that they did not take the matter of speed, and a few other little things, into consideration.

To get the right idea of how an airplane flies you must know about the properties of the air, the machine that is to fly in and through it and the forces that act on them. By getting these facts well in mind you will readily grasp the simple theory underlying mechanical flight and so we'll start with the air.

**The Ocean of Air We Live In.**— It seems that nature created the air, or *atmosphere* as it is called, that surrounds the earth like the sugar coating of a pill, especially so that man and the lower animals might breathe it and live.

Or, mayhap, the animal kingdom, having been evolved some millions of years after the air was formed was made so that it might breathe it and live. A nice thought to split hairs over, but at any rate which ever way these things came about they are certainly well suited to each other.

But the air is not only good to breathe for among many other uses it provides the *oxygen* for making fires, *nitrogen* for fertilizing plants, it diffuses the sunlight and so tempers the heat by day and the cold by night and not least, though it came last, it furnishes us with an admirable medium by, in and through which we can travel in a more direct line and at a greater speed than it is possible for us to do on the surface of the earth.

The air is indeed a great ocean for it reaches into space from sea level to a height of something like 50 miles, while astronomers have found traces of air that have rolled in gigantic billows to upwards of 200 miles.

At the bottom of this great aerial ocean do we live but we are no longer limited to travel in two directions that is lengthwise and across, for we can now get in an airplane and go up and this puts us in the class of three dimensional beings.

**The Physical Properties of the Air.**— By *physical* is meant the science of matter and motion and by *properties* are meant those things about matter which make various kinds either alike or different from other kinds. In a word then the physical properties of the air mean the scientific facts concerning it.

Now since all gases are formed of matter and what we call the air is a couple of gases mixed together, it follows that it has that property of matter called *extension,* that is, it takes up room, in sooth it takes up much room for however small the amounts of gases may be they always fill the vessels which contain them.

*The Weight of the Air.*— Another property of the air is *weight* and this keeps it on the earth's surface. Air weighs about 1/770th as much as an equal volume of water and about 1/1000th as much as an airplane which displaces it.

As the air extends to a height of some 50 miles above the earth's surface the weight of it is very close to 15 pounds to the square inch. With the air pressing on your body with a force of 15 pounds to every square inch you may wonder why you cannot feel it but the reason you can't is because it presses on all parts of your body up and down and on the sides with equal force.

Hence the weight of the air does not hold an airplane down but because it has weight, which gives it inertia, it helps to hold it up.

*The Inertia of the Air.*— Since the air has weight it must also have inertia. When matter in any form is at rest it tends to remain so and when it is in motion it tends to keep on going; this property of matter is called *inertia.*

As an illustration of this property you know of course that a ball cannot move of its own accord, and it is just as true that when you throw a ball it cannot stop of its own accord. In other words, to make the ball move you must apply some force to it, as for instance with your muscles when you throw it.

To stop the ball once it is in motion it must hit a bat, be caught, meet with the resistance of the air or be pulled to earth by the force of gravity. This, then, is how inertia makes a ball behave.

A simple experiment to show the effect of inertia is to take a card and put it on the tip of the index finger of your left hand; lay a penny on the card directly over the top of your finger as shown in Fig. 120. Now give the edge of the card a sharp snap with the index finger of your right hand when the card will sail away leaving the penny on your finger.

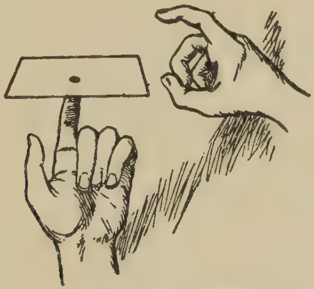

FIG 120.—AN EXPERIMENT IN INERTIA

The explanation is as simple as the experiment, as you will guess; the card moves so quickly it does not have time to impart any of its motion to the penny and so it sailed away and left the coin behind.

This is exactly the way it is with the air when an airplane moves through it at high speed, that is, the air does not have time to move and slip away from under the planes of the machine and the result is the machine glides over it as you may have done when skating over thin ice.

**About Matter, Speed and Force.**— A mass of matter or *body* as it is called, is said to be in motion when it constantly changes its position and keeps moving from one plane to another; hence when an airplane is flying it is, of course, in motion.

The *speed* of a body is its *rate of motion* and this is also called its *velocity.* The distance covered by a moving body, that is the space over which it passes depends on two factors and these are (1) the *speed* of it and (2) the *time* it takes.

*Force* means any action that can start a body to moving, change its direction or make it stop. Thus it takes force to start an airplane and force to drive it through the air and both are furnished by the power of the engine which turns the propeller. The forces that hold back an airplane and tend to stop it are those of gravity and the resistance of the air.

Finally when a body keeps moving along it gathers force, simply because it has inertia and this quantity is called *momentum.* The momentum of a body is proportional to the mass of it multiplied by its velocity, or, to make it clearer let $m$ represent the mass of the body and $v$ its velocity then the product of $m \times v$ will be the quantity of its motion and this is its momentum.

**How a Kite Flies.**— When you fly a kite it stands still and it is held up and out by the force of the *wind,* which is a body of air in motion and you hold the kite by a string so that the wind has to blow against it and also to keep it from getting away.

Ordinary kites have *tails* to balance them so that they will not be top heavy for if they are heavier at the top than at the bottom they will dart and dive and at best fly badly. When a well balanced kite is flying the wind strikes all parts of the front surface equally and then flows around the edges as shown in Fig. 121.

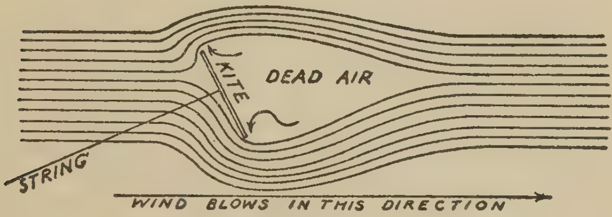

FIG. 121.—ACTION OF THE WIND ON A KITE

The air does not flow in close back to the kite but streams out around it and the lines of force meet at some little distance in the rear. Thus a space is left back of the kite in which there is *dead air,* that is, air that is not in motion. Now while this dead air has no particular effect on a kite it has an untoward effect on an airplane when it is flying as you will see directly.

**How an Airplane Flies.**—*Lift and Drag.*—A simple experiment to show the first principles of how an airplane flies is given by Commandant Duchêne in his "Flight Without Formulæ."[1]

To make the experiment put your hand in a tub of water, hold it so that it makes a small angle with the surface and then move it quickly forward. See Fig. 122. You will find that while your hand is very nearly horizontal and you are moving it through the water in a horizontal direction you can feel the water push it up.

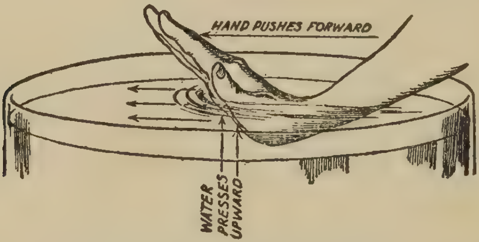

FIG. 122.— AN EXPERIMENT SHOWING THE UPWARD PRESSURE OF FLUIDS

Now this same action takes place when an airplane is flying, that is, the planes are set at a slight angle to the line of flight and the machine is then forced through the air by the propeller. While the planes meet with head resistance of the air, or *drag* as it is called, it also makes the air exert an upward pressure and so pushes up on them and this is called the *lift*.

**What Aspect Ratio Means.**— The proportion of the length of a plane to its width is called the *aspect ratio*. Where a plane is long for its width, as shown at A in Fig. 123, there is not so much leakage of the air over and around its leading edge and ends as where it is short and wide as at B.

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[1] Published by the Macmillan Company, New York.

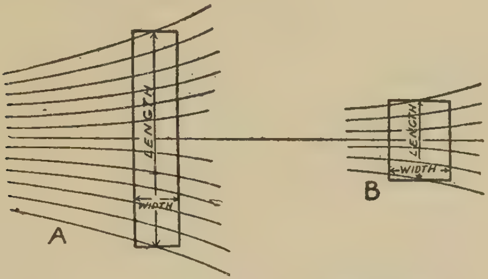

Fig. 123.— Diagrams of Aspect Ratio

**The Advantage of Stream Lines.**— If a flat surface like a kite was used for the plane of a machine the dead air above it will press down on and hold it back by virtue of its increased resistance as shown at A in Fig. 124.

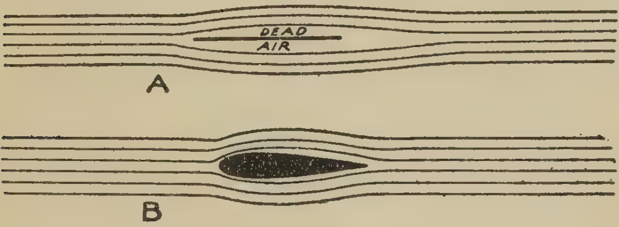

Fig. 124.— How Head Resistance Acts

But when the planes are curved the air sticks closely to both surfaces as shown at B, and this greatly lessens the head resistance, or drag. For the same reason all parts of the machine should be built with *stream* lines as they are called so that each part will offer as little resistance as possible as it moves through the air.

**How Cambered Planes Act.**— Not only does a cambered plane, that is one having a curved surface, possess a stream line top but its hollow under surface increases the lift by forming a sort of pocket for the air.

**The Speed and Motor Needed.**— The speed at which an airplane can fly depends on three *characteristics* as they are called and these are (1) the weight of the machine; (2) the area of surface contained in the planes and (3) the angle of incidence at which the planes set.

Now to make an airplane fly in a horizontal line the machine must be propelled through the air at a speed high enough to give the planes sufficient lift to raise the weight of the machine, that is the weight must be exactly equal to the lift.

All of the power developed by an airplane engine is not *useful power* since in the best engines much of it is wasted in heat losses, friction, etc. Then there are losses of power in the propeller due to slippage, etc., and these losses of the power plant must be allowed for. Certainly whatever the rated horsepower of an engine may be it must deliver enough power to drive the machine fast enough so that it will overcome the head resistance.

**When an Airplane Flies.**— *How the Start is Made.*— When an airplane is to make a start, or *get-*

*away* as it is called, the pilot sets up the *spark-lever,* or *sparker,* to *advance the spark* [2] and the *throttle* of the engine to give it plenty of gas, just as you do when you are ready to start your motor car engine.

His mechanic then *spins* the propeller, that is he turns the propeller rapidly around, which serves the same purpose as cranking the engine and the other assistants hold the machine until the pilot gives them the word to let her go.

The machine then starts off and runs along the ground and increases its speed as it goes. The first thing that happens when it is going fast enough is that its tail is lifted off the ground, the pilot then raises the elevation plane a little and this brings the nose of the machine into the air when it clears the earth and sails up and away.

*How a Turn is Made.*— You have often noticed when you ride a bicycle that on making a turn you lean in toward the center of the curve you are making, as shown at A in Fig. 125, so that you and it will not fall over on the other and outer side.

The reason you do so, whether you understand the principle of the thing or not, is to counterbalance what is called *centrifugal force.* Now Newton's *first law of motion* says that "every body of *uniform motion keeps in a straight line* (after it is started) unless it is made to change its direction by some outside force."

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[2] This is all explained in detail in my book, "Motor Car Starting, Lighting and Ignition," published by D. Appleton and Co., New York.

When you see the water flying from a rapidly turning grindstone or mud shooting off from a motor car wheel you have a very good illustration of what this law means. This tendency of moving matter to keep on in a straight line and hence, *farther away* from the center around which it is turning is called *centrifugal force.*

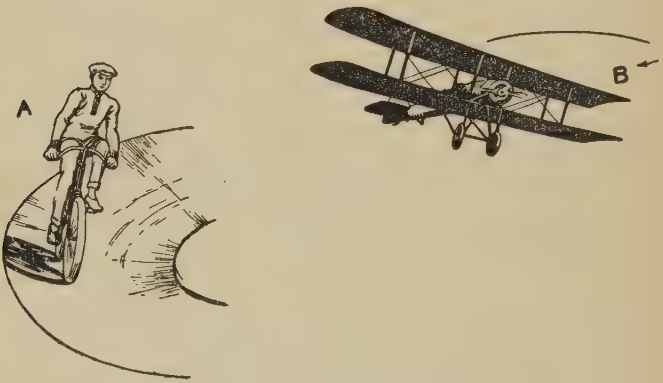

FIG. 125.—HOW AN AIRPLANE MAKES A TURN
A. Banking a Bicycle
B. Banking an Airplane

When an airplane makes a turn in the air it follows precisely the same laws that a bicycle or a motor car does when it is performing a similar maneuver on the ground — that is, it must be tilted inward, or banked as it is called, toward the center of the curve it is making, as shown at B, or else it will lose its sidewise balance and fall.

To make a turn not only is the rudder used but the *ailerons* as well, that is, the inside one, which is the one nearest the center of the curve, is pulled down and the other and outside one is kept even with the main plane.

When the machine is thus banked to overcome the *centrifugal force* of the curve it is making, the plane offers less surface to the air than when it is flying in a straight line and the leakage of the air supporting it is greater; hence the lift is smaller.

Moreover the outside half of the plane moves faster than the inside half of the plane and all of these conditions tend to make the machine slip against the pressure of the air and once that it starts to slip it wants to slip the more. To prevent it from doing this to the extent of getting beyond control, the pilot pulls the inside aileron straight and the outside one down which gives the first half of the plane more surface and the second less surface and this brings the machine to a level again.

*The Gliding Angle.*— When the engine of an airplane stops, the machine does not fall if it is handled right but instead, it glides to the earth.

Now every airplane has a certain natural angle at which it glides to earth when the engine is not running exactly the same as when it is flying straight ahead under the power of its engine and this is called its *gliding angle.* See Fig. 126. This is the safest angle then that a pilot can take when he is making a landing.

By the time the machine gets within a hundred feet or so of the ground it is going about as fast as it flies when driven by the engine on the level. The pilot then tilts up his elevation plane sharply and this makes the airplane glide at a very small angle with the surface of

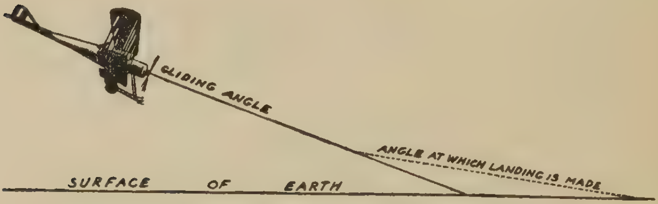

FIG. 126.—THE GLIDING ANGLE

the earth as shown by the broken line in Fig. 126, when it strikes the ground very gently and makes an easy landing.

## CHAPTER XIII

# INSTRUMENTS USED ON AIRPLANES

In the early days of the art, a pilot made his flights without the use of instruments of any kind and he relied solely on his sense of *feel,* which is a sort of instinctive judgment concerning the position and height of his machine.

All this is changed now and while a pilot ought to and does fly by the feel of his machine he has several instruments to tell him the direction he is going, how high up he is, how much his machine slopes fore and aft, how much it slants to one side or the other, how fast the engine is running, what speed the machine is making through the air, and what the amount of drift, set up by the wind, is.

**The Aneroid Barometer or Altimeter.**— Since air has weight, of course the pressure of it can be measured and since the higher up you go the less it weighs, it must be clear that if you can measure its pressure and you know what the pressure of the air is at different heights you can tell what the *altitude,* as the height is called, is.

Now an instrument for measuring the pressure of the air is called a *barometer* and it was invented in the long ago. Scientists have figured out the weight of the air at various heights and so with an aviation barometer a pilot only needs to glance at it to know exactly how high up he is.

Barometers are of two kinds, namely (1) those having a column of mercury and (2) those having a vacuum chamber. As a barometer of the mercury column type must have a tube nearly three feet long, is very heavy and must always be kept in an upright position, it is evident that it could not be used for airplane work. A barometer of the vacuum chamber type, though not as accurate, is very small and light and hence it is admirably adapted for this particular kind of service.

A barometer of the vacuum chamber type is called an *aneroid*[1] *barometer*. The principle it is made on is like this: a round metal box, about the size of a shoe-blacking box is fitted with a thin *corrugated*[2] cover. A strong hard steel spring is fixed to the bottom of the box and to the center of the cover. The cover is then sealed on the box and the air is pumped out of it.

One end of the lever is fixed to the upper end of the spring and the other end of it engages and works another lever which in turn is hooked on to a very fine chain and the latter is fastened to a hand, or needle, or pointer, as it is variously called. Finally a coiled hair spring is secured to a standard and to the needle and this keeps the chain taut, all of which is shown in Fig. 127.

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[1] From the Greek and means having no liquid; that is it has no mercury.

[2] Having parallel ridges and grooves.

Its operation is like this: the pressure of the air, which you will remember is 15 pounds to the square inch at sea-level, presses in the cover and pushes the needle to zero when the instrument is at sea-level. As it is carried higher the pressure of the air grows less, the cover rises accordingly and the needle points to the pressure marked on the dial.

In aneroid barometers built for practical use instead of for classroom demonstration as above described, all of the mechanism is placed inside the vacuum chamber so that it is very small and compact.

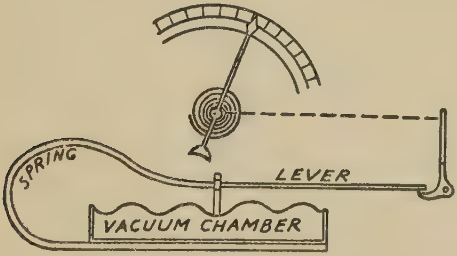

Fig. 127.— A Demonstration Aneroid Barometer

Different from a mercurial barometer whose scale is marked off to show the height of the mercury in the tube in fractions of an inch the dial of an aneroid barometer is marked with the altitude (height) in feet so that when the needle is on 1 the pilot knows he is up 1000 feet, etc., as shown in Fig. 128.

The kind of airplane altitude barometers used in the *U. S. Navy* and *the U. S. Signal Corps* has an inner dial treated with a *radio-active compound* and a hand of the same material. By its use the pilot can easily read the dial at night when he is flying without lights.

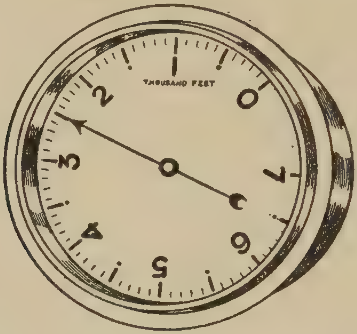

FIG. 128.— AN AIRPLANE ANEROID BAROMETER

**The Airplane Compass.**— A compass in its simplest form is merely a magnetized steel needle pivoted in its middle so that it can turn freely. A demonstration magnetic needle of this kind is shown in Fig. 129.

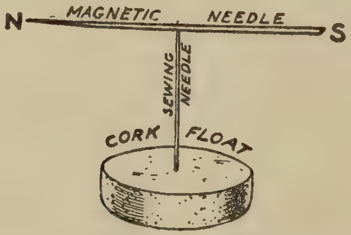

FIG. 129.— A DEMONSTRATION COMPASS

Such a needle always points to the magnetic North Pole and hence it has long been used to determine directions on the earth's surface and it is just as useful to men who navigate the air.

An airplane compass is made very like a mariner's compass in that the magnetic needle is really a magnet, and a disk, or *card* as it is called (see Fig. 130), on which are marked the 32 points, or *rhumbs,* is fixed to it and, consequently, turns with it. This magnetic system is pivoted in a bowl and this in turn sets in trunnions which allows it to always keep a level position; the whole works are then enclosed in a metal case like an alarm clock.

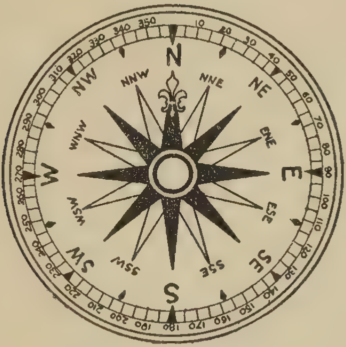

FIG. 130.— CARD OF AN AIRPLANE COMPASS

A vertical line, called a *lubber line,* is marked on the inside of the bowl and the compass is set in the airplane with the lubber line toward its nose so that if you laid the edge of a rule on the lubber line and on the pivot of the card it will be parallel with the keel of the fuselage. A pilot reads his compass from the lubber line.

Now while a pilot can always tell what direction he is going through the air by consulting his compass he is apt to make a very bad *landfall*[3] if he tries to use it to fly over a given course. There are three factors the pilot must take into consideration in flying over a course by compass and these are (1) its *variation* and (2) its *deviation*, and (3) the *drift* of the machine.

*Corrections* for the first two are quite easy but the last one is a dead hard game. Now let's find out what they mean. (1) By variation is meant the angle between the *true* and the *magnetic* meridians. The true meridians are the imaginary lines running round the earth and which meet at the North and the South poles.

The magnetic meridians are real magnetic lines of force that flow in, on and above the surface of the earth and instead of meeting at the true North Pole, they meet at a point in the extreme northern part of North America. To find the true north, then, a correction must be made, which means that the difference must be figured out, and while this is simple enough on board a ship it is a hard thing to do when flying.

(2) As the engine and other parts of an airplane are made of iron and steel the compass needle is attracted to a certain extent by them. This local attraction is called *deviation* and this further adds to the inaccuracy of the compass. To correct for it a *deviation card*, as it is called, is used with the compass and

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[3] When the navigator of a ship lands where he calculated he would he makes a good *landfall*. This is also true of the pilot of an airplane.

this shows how many degrees the needle is out of its true course which is different for different points of the compass.

(3) The *drift* is the extent to which an airplane is driven out of its course by the wind. There are two ways to correct for drift and these are (1) by laying off a course and allowing for it, and (2) by using an *airplane drift set*. The way to use a compass to the best advantage is a branch of *acrial navigation* and is a study in itself.

**The Airplane Drift Set.**— Because side winds are of different velocities it is quite impracticable to allow for them when a course is laid out. To the end that the actual drift could be known and corrected for, the *Sperry Gyroscope Company* of New York devised the *drift indicator* shown in Fig. 131.

This instrument consists of a telescope fixed to the airplane so that the pilot can get a good view of the ground. Five parallel hairs are fixed across the lenses in the telescope and when the machine is flying and the pilot looks through the telescope it appears that all the objects on the surface of the earth were built in straight lines.

By turning the adjusting screw so that the parallel hairs are in a line with the apparent line of objects, the angle between the course laid out and the line of flight the airplane is making due to drift is given.

A flexible steel wire shaft connects the telescope with an *adjustable lubber* line, that is a line drawn on the inside of the bowl. Now when the pilot adjusts the telescope, the flexible shaft shifts the lubber line and the amount of drift can then be read from the compass.

**Airplane Incidence Indicator.**— This is a Wright instrument and its purpose is to show the slope or angle of the machine fore and aft with the surface of the earth.

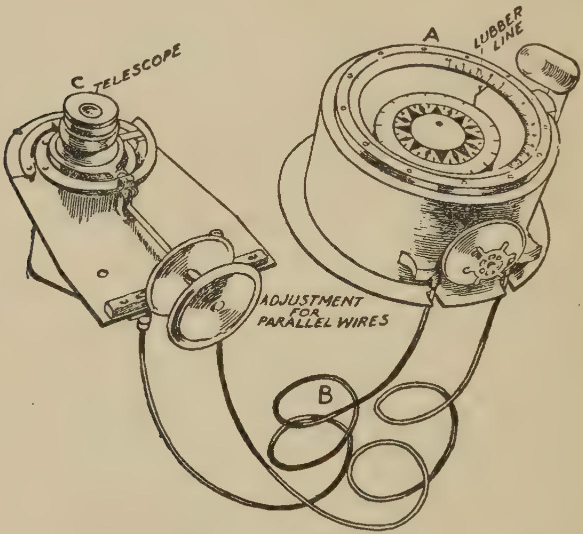

FIG. 131.— AN AIRPLANE DRIFT INDICATOR (SPERRY)

It consists of a little vane fixed to the end of a rod which is pivoted near the other end which is weighted, hence it is always parallel with the earth's surface, whatever the position of the machine. A hand is fixed to the pivoted shaft and it moves with the bar.

A dial marked off into degrees is fixed to a stanchion and as the machine slopes up or down the dial moves across the hand which shows the pilot the angle of his machine with reference to the surface of the earth.

**Airplane Inclinometer.**— This instrument serves the same purpose as the incidence indicator just explained, that is, it shows the slope of an airplane referred to the horizontal.

It is made like an ordinary level except that it has a curved glass tube instead of a straight one and contains a red liquid instead of a colorless one. It is mounted on top of a metal case, the front plate of which is marked off in divisions of 10 degrees in each direction. Two of these inclinometers are usually fitted to each airplane — one ahead of and one beside the pilot.

**Airplane Laterometer.**— This instrument, which shows the change of slope in the sidewise position of the airplane, is likewise a modification of the spirit level.

When the pilot is making a turn, as long as he banks the machine so that it does not side-slip, the bubble will stay in the middle of the glass tube, that is, at zero, but if he does not bank the machine enough the bubble will move to the right or the left of zero depending on the direction he is turning and the number of degrees shows the amount of the slippage.

**Engine Revolution Counter.**— A *revolution counter* is used to enable the pilot to know how many revolutions the crankshaft of his engine is making. A flexible shaft leads from a worm gear on the crankshaft to a counter box where the pilot can see it. The flexible shaft is connected to a governor in the box; pivoted to the governor shaft is a hand and under it a dial, marked with the number of revolutions per minute for various speeds of the engine, is fixed.

Now when the speed of the engine increases the flexible shaft makes the governor balls fly farther apart and this forces the governor shaft down and when the engine slows down the balls fall and the governor shaft rises; these up and down movements of the governor shaft moves the needle over the dial.

**Airplane Speed Indicator.**— This instrument shows the pilot the speed his machine is making through the air but not the speed it is making over the surface of the earth.

In all of our measurements of the speed of things on the earth's surface we simply figure the distance covered in a given length of time. But not so with an airplane for the velocity of the wind blowing against it must be subtracted from the speed it is actually making, or *air speed* as it is called, in order to find the speed of it over the ground.

The instrument consists of two tubes fixed to the leading edge of the main plane and one end of each tube is open and forces the wind so that the latter can blow into it; the other ends of the tubes are connected to a box divided in the middle by a leather disk called a *diaphragm*.

The first tube is open all the way through to the box while the other tube has a funnel fitted to its free end in such a way that when the wind blows into the mouth of it, it sets up a suction instead of a pressure.

A needle is fixed to the center of the diaphragm and is attached to a lever which in turn is connected to a hand moving over a dial which has miles per hour marked on it like a motor car speedometer.

Now when the machine is winging its way through the air the wind blows down the first tube against the diaphragm, and the suction of the second tube pulls on the diaphragm; these positive and negative pressures of the air on the diaphragm move it accordingly and the hand on the dial indicates the speed of the machine.

## CHAPTER XIV

## SOME RECORD AIRPLANE FLIGHTS

Just as soon as the Wright Brothers had made their first secret flights, stories were in the air concerning them and many men at home and abroad set to work to make airplanes for themselves and fly like them.

**The First Wright Flights.**— The first time in the long history of the world that man ever flew in a power-driven heavier-than-air machine was in December, 1903, when the Wrights put a 16-horse power engine in and a pair of propellers on one of their gliders and made a flight over the sand dunes at Kitty Hawk, North Carolina.

The first time this airplane flew it remained in the air just 12 seconds; two more flights were made the same day which lasted a little longer and then came the climax when in their fourth flight nearly 1000 feet was covered in the teeth of a wind blowing 20 miles an hour and which lasted 59 seconds.

From this time on until 1906, the Wrights made private flights to test their machine prior to obtaining patents on it and the longest distance they covered was 24 miles at a speed of nearly 40 miles an hour. Satisfied with the construction of their airplane they took it apart while their patents were pending.

**Santos-Dumont Shows Europe How to Fly.**—The first man in Europe to get off the ground in a powered heavier-than-air machine was the nervy and spectacular Santos-Dumont, who had previously circled the Eiffel tower in his lighter-than-air machine in 1901.

But the thing that made him switch over from the airships to the airplane was a prize of 3000 *francs* (about $600), that M. Archdeacon had offered in 1903 to the first aviator who would fly 25 *meters* (about 75 feet). No one tried to win it until 1906 when Santos-Dumont concluded to take the money and at the same time show Europe how easy it was to fly.

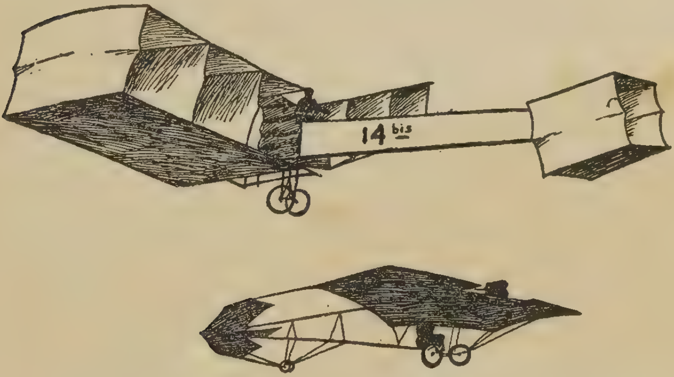

FIG. 132.—SANTOS-DUMONT SHOWS EUROPE HOW TO FLY
A. The Upper Picture Shows Santos-Dumont's First Airplane
B. The Lower Cut Shows His Little *Demoiselle*

He built a box-kite-like airplane (see Fig. 132), and put a motor in it which developed 50 horse power.

His idea of how to fly was a little different from that of the birds in that he proposed to make his machine fly tail foremost.

With but one previous trial flight he piloted his machine through the air at the rate of nearly half a mile per minute for a distance of 200 feet and so easily won the prize.

This achievement fired the sporting blood of those interested in flight with the result that the *Aero Club of France* offered a prize of 1500 francs to the first aviator who should fly over a stretch of 100 meters. Santos-Dumont also won this prize by flying more than twice the distance.

**Henri Farman Wins the Kilometer Prize.**— MM. Deutsch and Archdeacon together then offered a prize of 50,000 *francs* to the aviator who should be the first to fly over a course of 500 meters and return — making a kilometer[1] (about ⅝ of a mile).

On January 13, 1907, before the members of the *Aero Club of France* Henri Farman flew in a biplane over the first half of the course, made a beautiful turn and returned to the starting point, thus winning the prize.

**Delagrange Flies With a Passenger.**— The first time a passenger was ever carried in an airplane was in March, 1908. Leon Delagrange had become a rival of Farman's but not being able to beat him at straightaway flights he offered to take him as a passenger for a spin in his machine. Farman accepted and flew with him for some 50 meters and thus a passenger record was made.

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[1] A kilometer = 1000 meters.

Delagrange, however, finally outdid Farman by flying over a course of 5575 meters in 9¼ minutes. He then went to Italy and Farman to Belgium where they both broke their own previous records and by the end of 1908 the former covered a distance of almost 15 miles in about 30 minutes and the latter had made 25 miles in 44½ minutes.

**Other 1908 Record Breaking Flights.**—Farman was the first, however, to fly from one town to another which he did in September, when he made the trip from Chalons to Rheims, a distance of 27 kilometers in about 20 minutes. The next day he made an *altitude flight,* that is, he flew as high as he could, in which he reached a height of about 100 feet and thereby won a prize of 500 *francs.*

**The First Public Flight in America.**— In 1907, a number of men including Alexander Graham Bell, the inventor of the telephone, Glenn H. Curtiss, Lieutenant Selfridge, U. S. A., and Messrs. Baldwin and McCurdy of Canada, formed what they called the *Aërial Experiment Association,* the purpose of which was to build an airplane that would fly.

The first machine the Association built was called the *Red Wing* and in March, 1908, Curtiss piloted it through the air to a distance of 319 feet. There were a couple of dozen people who saw the flight and as there was no secrecy about it, it was the first public flight of a man-carrying heavier-than-air machine in America.

**The Wrights' Wonderful Public Flights.**— Having taken care of their patents the Wrights began to fly again in May, 1908. After practicing awhile with their old machine, they built a couple of new ones; see the picture at the end of this chapter.

Orville Wright went to Fort Meyer, Virginia, and Wilbur Wright to Le Mans, France, to make some public flights, the purpose of which was to demonstrate the flying qualities of their machine to the *U. S. War Department* and to a French syndicate respectively.

On September 9, Orville Wright made two wonderful flights in which he sailed for 57 minutes and 31 seconds, the first trip, and for 1 hour and 3 minutes the second trip.

Wilbur Wright made his phenomenal flights a few days after and broke all previous records by flying over a distance of 52 miles and staying in the air for 1 hour, 31 minutes and 25 seconds.

After he had made many flights, long in both time and distance, he carried a passenger up with him and remained in the air for 1 hour and 10 minutes and finally to cap the spectacular performances he won, on December 31, 1908, the Michelin purse of 20,000 *francs* for the longest flight of the year.

**Blériot's Great Cross Channel Flight.**— The outstanding flight of 1909 was that which Louis Blériot made across the English Channel in his *No. XI* monoplane a model of which I described in Chapter V.

The *London Daily Mail* had offered a prize of 1000 francs ($5000), to the first aviator who should fly from France to England, a distance of 22 miles. Now at that time the two most daring aviators in France were Blériot and Hubert Latham.

Latham was the first to attempt the feat and made his getaway on July 19; he had not flown far over the English Channel when his engine *stalled* and he volplaned down to the water where he was picked up by a torpedo boat destroyer.

A week later, that is to say, on July 25, Blériot left Calais on the coast of France *via* the air for Dover on the coast of England. The wind drove him out of his course but in less than an hour he landed at Deal, thereby winning eternal fame for himself and his monoplane. See Fig. 133.

If you ever go to Deal you will see a silhouette of a Blériot monoplane of the same size as the one he crossed the Channel in hewn out of white stone, marking the identical spot on which he landed.

In the year of 1909 many other notable flights were made especially at the first *International Aviation Meet* but it would take a whole book of this size to tell you about all of them.

**The Altitude Exploits of 1910.**— Before 1910, aviators had made time and distance records but none of them had made any really high flights and so *altitude flights* were next in order.

At the beginning of the year no one had flown as high as 3000 feet and consequently when Latham flew his monoplane to a height of 1050 meters (about 3500 feet) he set a new altitude mark. From that time on throughout the year, higher and ever higher altitudes were reached and old records were broken by one aviator after another until Arch Hoxey flying in a Wright biplane at Los Angeles, California, made a new record

Fig. 133.—Blériot Crossing the English Channel

on December 26, when he reached a height of 11,474 feet, or over 2 miles.

**The Speed Tests of 1910.**— The speed records of 1910 also made a most remarkable showing for now machines were designed and built with planes having small surfaces and engines having high power.

In 1909, Curtiss flew at a speed of 47 miles an hour at Rheims and this was considered very fast but it was eclipsed right along by other aviators until before the year was done a mile-a-minute rate had been attained.

During the following year this high speed record was beaten by Morane at the Rheims meet, when he flew at the rate of 66 miles an hour. Then Le Blanc at Belmont Park, New York, made a speed of 71½ miles an hour on one of his laps when flying over a course of 5 kilometers; and, finally, before the close of the year speeds were made in the neighborhood of 75 miles over short distances.

**Some Distance Flights of 1910.**— The first performances of airplanes had proven that they could fly high and fly far and to stimulate practical flying, that is, town to town flights, the great newspapers of the world began to offer large cash prizes.

The *London Daily Mail* offered a prize of £10,000 ($50,000) to the aviator making the first flight from London to Manchester. The distance was 183 miles, and 24 hours and two stops were allowed in which to make it.

In those days few aviators cared to attempt so long a flight cross-country, but Claude Graham-White of

England and Louis Paulhan of France decided the prize was of more consequence than anything else that men like to hold on to.

So late one afternoon in April, both pilots started from London in what proved to be the first long distance airplane race. After much maneuvering, Paulhan won out, having made the trip in a little over 4 hours actual flying time and the prize money was awarded to him.

The *New York World* had offered a prize of $10,000 for an airplane trip from Albany to New York, a distance of 128 miles, with two stops allowed and Curtiss determined to try for it.

His airplane was fitted with airtight copper cylinders, or pontoons as they are called, mounted under the lower main plane so that in the event of having to make a landing on the water it would float. On a May morning he started from Albany, following the Hudson River. He flew for 40 miles and then landed to take on oil and gasoline.

This done he was soon in the air again and flying at the rate of 50 miles an hour the rest of the way, he landed at Spuyten Duyvil which is the northern outskirts of New York City, and the prize was his. Just for good measure he started again and flying down the river at high speed he landed on Governor's Island.

The most thrilling town to town flight was made by George Chevez, who piloted a Blériot monoplane across the Alps. The *Italian Aviation Society* had offered a prize of 70,000 *francs* for a successful flight from

Buig, Switzerland, to Milan, Italy, a distance of only 75 miles, but with the lofty Alps between them.

Other aviators before Chevez had tried for the grand prize and because of adverse winds or overhanging fog they failed. But on a beautiful September day, Chevez soared up and over the Alpine heights and in less than 20 minutes he was sailing down the Italian side to the town of Domodossola where he intended to make a stop before going on to Milan.

Just as he was about to land his machine it was seen to crumple up and then it fell heavily to the ground with Chevez pinned under it. He was badly injured and passed away a few days after.

**The Invention of the Hydroplane.**— To Curtiss is due the credit of having been the first to put pontoons under his machine and to land on the water which he did in 1909.

As with everything else there was strenuous competition to see who should be the first to rise from the surface of the water in an airplane and the most formidable rival that Curtiss had was Henri Fabre of France. Both were working hard on the problem but Fabre was the first to succeed.

In March, 1910, the Frenchman put three floats under his monoplane and with this *hydroaëroplane* as it was then called, but which has since been shortened to *hydroplane* or *seaplane,* he was able to rise from the water.

On February 1, 1911, Curtiss put a single large float under his airplane and launched it on San Diego Bay,

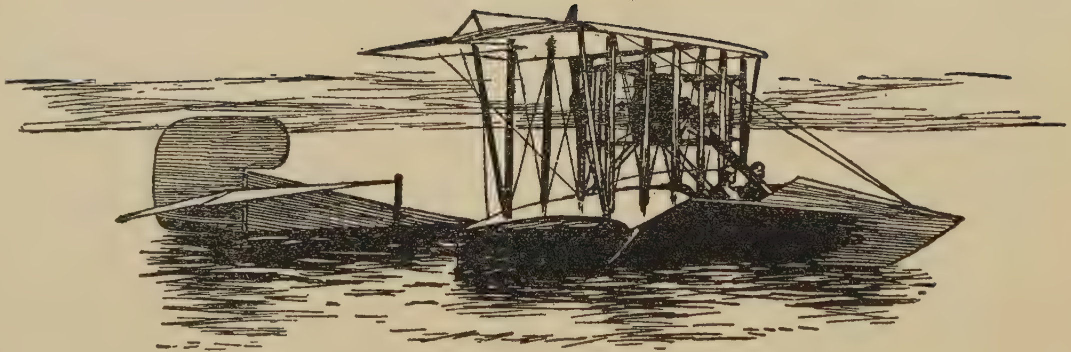


FIG. 134.—THE CURTISS FLYING BOAT

California. After skimming along the surface a little way the machine rose from the water with ease and thus a new branch of the flying art was born.

Later on Curtiss mounted the biplane wings on the hull of a boat and this is the type of flying craft that is shown in Fig. 134.

# CHAPTER XV

## THE VARIED USES OF AIRPLANES

**Flying Before the War.**— When the airplane was first invented it was commonly believed that in a short time everybody would be flying about just as everybody was motoring around.

But the airplane is a very different proposition from the motor car in that you need a big field to *take off,* for the machine must not only run along the ground until it gets up the necessary speed to carry it into the air but as it begins to rise it flies at a small angle and, hence, there must be no trees, buildings or other obstacles in the line of flight for some little distance. And for alighting even a larger field is needed.

It has been suggested that every city should have one or more fields on its outskirts for the especial use of aviators and from which they could reach the heart of the city by motor car, or subway, elevated or surface car, or shank's mare, which ever way the importance, health and wherewithal of the devotee of the art dictated.

Even with the question of taking off and landing disposed of, the airplane was and is, I believe, still looked upon by most folks as an untrustworthy mode of transit and the exploits of the exhibition fliers, each of whom, almost without exception, lost his life, did more to fix that untoward belief than any other one thing.

Thus most men with money love it and life too much to think of flying and it follows, conversely, that men who haven't anything to live for haven't the money to buy an airplane with. And there you are.

This about sums up the condition of the flying game before the World's War started in 1914 and because of these limiting features the general use of the airplane, either as a pleasure craft or as a means of getting somewhere quicker than by a motor car or a locomotive, was not very promising.

**The Airplane in War.**— If the people at large were not keen about the practical aspects of the airplane the governments of the various nations were deeply interested in its development for purposes of warfare but they did not get down to a real working basis until after the war had started.

That the airplane should provide eyes for the army and navy, just as wireless was the nerves of these services, was the first work mapped out for it to do, that is, an airplane could fly over enemy lines and see what he was doing, make sketches and maps back of the lines and gain other valuable information.

Then photography was added to the equipment of the machine and plates were made of the enemy's positions with a telephoto lens. On landing the plates were developed, lantern slides were made from them which were then projected on a screen when the details could be easily seen and excellent maps made from them which showed every feature from foot-paths to trenches and from woods to villages.

The next use to which military airplanes were put was for the pilot, or observer, who often goes with him to see where the shells hit which were fired at the enemy and to report the results back to its battery.

*Signaling To and From Airplanes.*— To signal from an airplane to the gun battery a wireless set is used but to signal from the battery to the airplane *panels* are employed.

A wireless sending set is installed on the airplane so that the observer can send messages to the ground, but as it is hard for an operator to hear incoming wireless messages in an airplane, owing to the noise of the propeller, a receiver cannot be used, but panels, that is a number of squares of cloth spread out on the ground in different positions which mean different orders, are used, as these can be easily seen and read by the observer.

To send wireless messages from and to read panels in an airplane the latter, after spotting the bursting shell, flies back and close to the wireless station which is connected with the battery by an ordinary wire telephone or telegraph system.

*Aircraft and Anti-Aircraft Guns.*— To prevent airplanes from making these scouting expeditions the airplanes of the opposing side were fitted with *automatic rapid fire guns,* chiefly of the Lewis type.

While one of these guns weighs only 26 pounds it fires a round of 97 shots continuously before another magazine holding a like number of cartridges must be snapped on it. Just as soon as it became the fashion to mount these guns on airplanes terrific battles began to be fought in the air and a new style of fighting was born.

Talk about Thermopylæ, Crécy and the Alamo! Why, boy, our young heroes of the air made the seasoned veterans of those bloody struggles rise up in their graves and applaud their bravery. It's all over now but their names will endure to the end of time.

Not only were rapid fire guns mounted in airplanes to destroy the machines of the foe but anti-aircraft guns, or *Archies,* as they are called, were fixed on tripods which set on the ground and these were also used to shoot down the enemy. The American aviators destroyed a total of 926 German airplanes and 111 war balloons while the war was on.

*Bombs and Bombing Planes.*— For blowing up submarines, buildings and the earthworks of the enemy explosive bombs were used and for setting fire to materials gasoline bombs were employed and these are dropped from airplanes, built for the purpose, on the enemy.

The bombs are held in frames fixed to the fuselage either under it or under the lower planes. A lever is arranged to release the bombs and the pilot does this at the right instant by looking through a *sight.* Owing to the weight of the bombs special airplanes

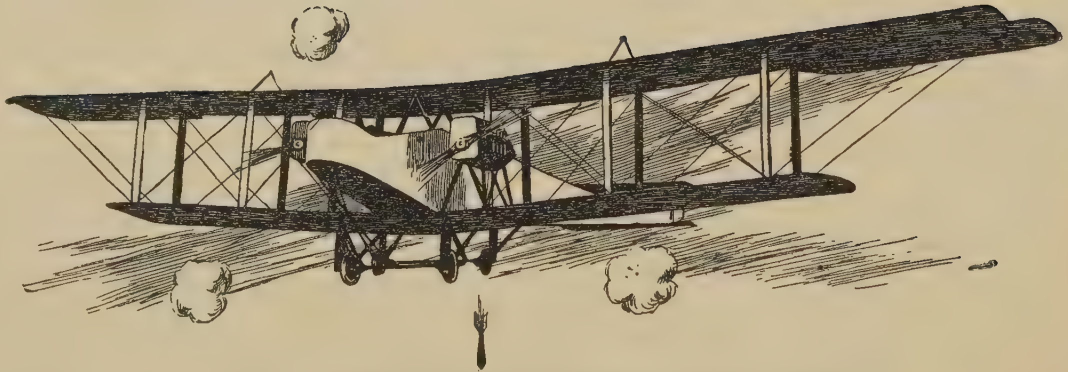


FIG. 135.—THE HANDLEY-PAGE BOMBING PLANE IN ACTION

of large size, called *bombers*, were used and of these the Handley-Page shown in Fig. 135 was one of the most efficient.

**The Outlook for the Future.**— *The Postal Service.*— Now that the war is over there are hundreds of skilled pilots and thousands of swift airplanes left idle and it would be a pity indeed if these daring men and costly machines could not be employed at once for some kind of useful work.

About six months before the war was over the government began a daily aerial postal service between New York and Washington. The schedule provided for a plane to leave each day from both New York and Washington. The first planes left at 11:30 on the morning of May 16, 1918, Lieutenant Webb starting for New York and Major Fleet from the Capital.

A little later airplane mail service was established between New York and Chicago and these flights were successful enough to encourage the government to plan new routes especially in Alaska.

In September, 1918, that branch of the *Postoffice Department* known as the *U. S. Aerial Mail Service* formally accepted the first six airplanes that were especially built to carry mail. This event not only marked the real beginning of the airplane mail service but also the beginning of the commercial manufacture of airplanes.

The air mail service is, then, the first practical use to which airplanes have been put and it will not be long before mail planes will be speeding in an air line between neighboring cities, across the continent and to and from the United States to Canada, Alaska and Mexico at the rate of 100 or 150 miles an hour.

**Passenger-Carrying Airplanes.**— You will remember I told you that Delagrange, in 1908, had taken his rival, Farman, for a little joy-ride in his airplane and thereby made history by being the first to carry a passenger in a heavier-than-air machine.

During the next year Farman had a big machine built and with it he broke Delegrange's record by carrying three passengers aloft with him. Almost every year from that time on the weight-carrying capacity of airplanes was increased until just before the war as many as 12 passengers were carried over short distances at a time — which is nearly as many people as you can get into a Ford touring car.

Even as I write — Nov. 18, 1918 — a cable from Paris states that a giant airplane carrying 35 passengers flew from Combes La Ville to Paris, a distance of 40 miles, and returned again making the round voyage without a hitch.

This record, it seems to me, shows very clearly the trend of travel by way of the air. That is to say, transportation companies will be organized and these will operate air lines between various cities. The first machines to be operated will carry from 1 to 10 pasengers and the fare, of course, will be according to the number carried and the mileage covered.

Airplane fares will naturally be higher than railroad fares but there are always those who feel that time is worth more than the extra fare and there are enough of this class to keep a fleet of airplanes busy between the larger cities.

These passenger machines driven by expert pilots will give the public their first taste of what frictionless, air-line, high speed travel really means and the public will not be long in appreciating the service either.

**Popular Individual Flying.**— Driving one's own airplane is not likely to become a widely popular mode of travel either as a matter of business or pleasure until some scheme for *automatically stabilizing* it has been invented.

I do not mean by this that a mechanical device like a pendulum or a gyroscope, both of which have already been applied to the airplane to balance it, is what is needed. Far from it, but rather the machine must be so designed that it is *inherently stable* — that is if a gust of wind should strike it and turn it over it would right itself before reaching the ground of its own accord.

It is perfectly possible *now* to design an inherently stable machine and the airplane manufacturers will come to it in due time. By the time such self-righting machines are built the price of them will drop and a single seater baby machine may be bought for a couple of hundred dollars if some master mechanic who knows how to systematize production gets on the job.

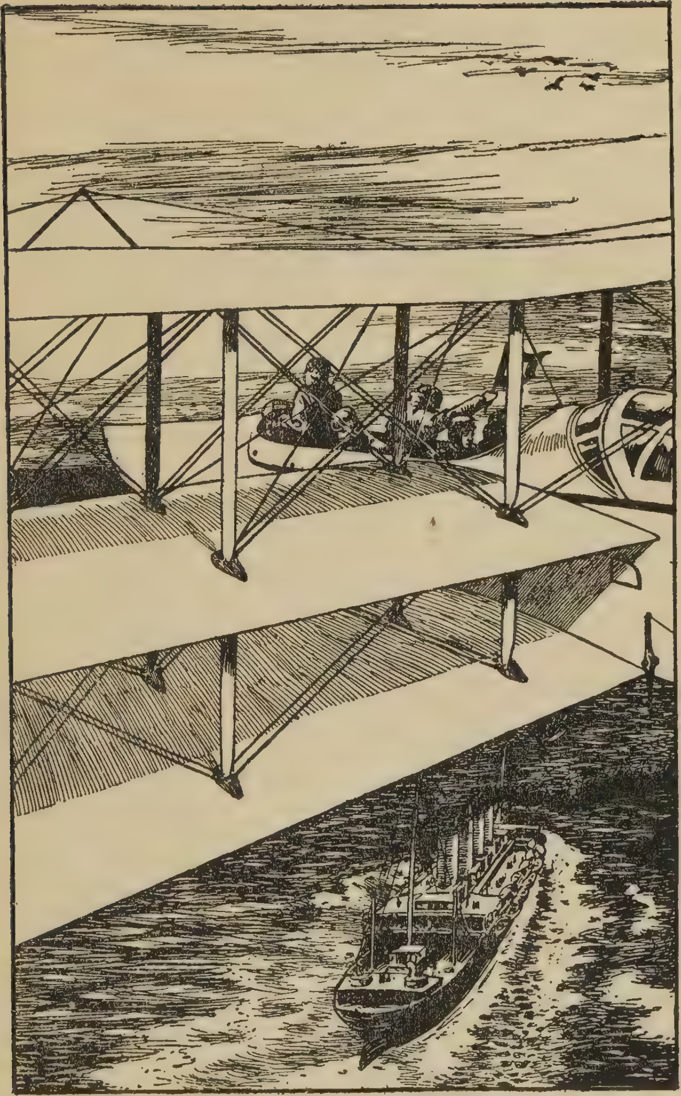
If my guesses are anywhere nearly right popular individual flying — that is when everybody flies as everybody motors now — will not be with us for a dozen or a score of years to come.

**Flying Across the Atlantic.**— The year before Mr. Hohenzollern concluded it was time to lick Europe and punish the United States, airplanes had been made and flown at such speeds and to such distances it seemed within reason that an aviator might successfully fly across the Atlantic.

To stimulate the desire to do so Lord Northcliff, the owner of the *London Daily Mail,* offered a prize of $50,000 to the first aviator to fly from the United States, Canada or Newfoundland and land either in Ireland or Great Britain. The conditions required that the flight should be made in 72 hours — about 40 miles per hour — and the aviator could alight as many times as he might care or have to. Evidently to attempt a transatlantic flight a hydroplane would be needed and it would have to be attended on the way by yachts or other vessels.

This gigantic undertaking was well under way in 1914 for a hydroplane had been built especially for the flight and an aviator had been chosen to pilot it. Then the war broke out and the proposed flight was called off.

The art of building engines and airplanes was exceedingly crude before the war compared with what it is at the present time and the pilots then couldn't begin to hold a candle to those who have been specially



Flying Across the Atlantic

trained during the war and just as soon as the world gets to running smoothly again there will come forth an airplane and a pilot who will try for the fame and money there is in it.

And after them will come others until at last a successful flight from the United States to Europe, or the other way about, will be made to the eternal glory of the man who offered the prize, the company who designed and built the machine and, greatest of all, to him who piloted the aircraft across the unbroken stretch of water that joins the Old and the New World together. And once the trip is made there will be no other honors left for aviators to strive for unless they want to fly to the moon.

THE END

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